

Philosophy not 7.
A

DISSERTATION

ON THE

Æ T H E R

OF

Sir ISAAC NEWTON.

By BRYAN ROBINSON, M. D.

L O N D O N:

Printed for CHARLES HITCH at the *Red*
Lion in Pater-noster Row.

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PREFACE.

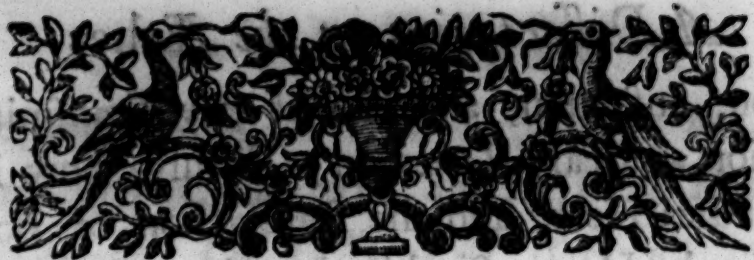
IN the following *Dissertation on the Æther of Sir ISAAC*

NEWTON, I have explained those Properties of it, which he has delivered in his *Optics*. This *Æther* being a very general material Cause, without any Objection appearing against it from the Phænomena, no Doubt can be made of its Existence: For by how much the more general any

P R E F A C E.

Cause is, by so much the stronger is the Reason for allowing its Existence. The *Æther* is a much more general Cause than our Air: And on that Account, the Evidence from the Phenomena, is much stronger in Favour of the Existence of the *Æther*, than it is in Favour of the Existence of the Air.

A



A
DISSERTATION
ON THE
ÆTHER
OF
Sir ISAAC NEWTON.

IN this Dissertation on the *Æther* of Sir *Isaac Newton*, I shall First give an Account of the Nature of an elastic Fluid ; Secondly, I shall shew how a subtile *Æther* causes an universal Attraction and Gravity ; Thirdly, how it causes Repulsion and Elasticity ; Fourthly, how it causes the principal Phænomena of Light, namely, its Emission, Refraction, Reflexi-
B on,

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on, Inflexion, and Fits of easy Transmission and easy Reflexion ; Fifthly, how it causes Heat, and the Rarefaction of Bodies by Heat ; Sixthly, how it causes muscular Motion and Sensation ; And, Seventhly and Lastly, I shall shew how it makes the Particles of Bodies to cohere, and causes Fermentation.

FIRST, I shall give an Account of the Nature of an elastic Fluid.

PROPOSITION I.

If a Fluid be composed of exceedingly small Particles of Matter, placed at very small and equal Distances from one another ; if all the Particles of one and the same Fluid, have equal Diameters and Densities, and be all endued with centrifugal Forces, by which they endeavour to recede from each other ; if this Force in the Particles do not extend beyond, but terminate in the Particles lying next to them ; and if the centrifugal Force of two Particles, or the Force with which they endeavour

deavour to recede from each other, be as their Density directly, and as their Diameter and the Distance of their Centers taken together inversely; I say, that the elastic Force of the Fluid will be directly as the Density of the Particles, and inversely as their Diameter and the Cube of the Distance of their Centers taken together; and that the same Force will likewise be as the Density of the Fluid directly, and as the fourth Power of their Diameter inversely. If E be put for the elastic Force of the Fluid, S for its Density, D and Δ for the Diameter and Density of the Particles, and C for the Distance of the Centers of those Particles which lie next to one another; I say that E will be as $\frac{\Delta}{D \times C^3}$, and likewise as $\frac{S}{D^4}$.

For the centrifugal Forces of the Particles of the Fluid being supposed to terminate in the Particles lying next to them; the elastic Force of the Fluid, or the Force with which it endeavours to expand itself, will be as the centrifugal Force of

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two Particles, and the Number of Particles lying in a plane Surface of a given Magnitude, taken together : But the centrifugal Force of two Particles, is by Supposition as $\frac{\Delta}{D C}$; and the Number of Particles lying in a plane Surface of a given Magnitude, is inverfly as the Square of the Distance of their Centers, that is as $\frac{1}{C^2}$: And therefore the elastic Force of the Fluid will be as $\frac{\Delta}{D C} \times \frac{1}{C^2}$; that is, E will be as $\frac{\Delta}{D \times C^3}$.

The Density of the Fluid, is as the Quantity of Matter in all the Particles contained in a given Space ; which Quantity of Matter, is as the Quantity of Matter in one Particle, and the Number of Particles contained in that Space taken together : But the Quantity of Matter in one Particle is as its Magnitude and Density taken together, that is, as $D^3 \Delta$; and the Number of Particles contained in the given Space, is inverfly as the Cube of the Distance of the Centers of two adjoining

joining Particles, that is, as $\frac{1}{C^3}$: And therefore, the Density of the Fluid will be in a Ratio compounded of $D^3 \Delta$ and $\frac{1}{C^3}$; that is, S will be as $\frac{D^3 \Delta}{C^3}$. Hence, $\frac{S}{D^3}$ will be as $\frac{\Delta}{C^3}$; or as E D, from the foregoing Measure of E : And consequently E will be as $\frac{S}{D^4}$.

The Proposition therefore is true ; namely, that E is as $\frac{\Delta}{D \times C^3}$, and likewise as $\frac{S}{D^4}$.

Cor. 1. If the Diameter and Density of the Particles be both given, as they will be in one and the same elastic Fluid by this Proposition ; then the elastic Force of the Fluid will be inversly as the Cube of the Distance of the Centers of the Particles, and likewise directly as the Density of the Fluid. If D and Δ be given, E will be as $\frac{1}{C^3}$, and likewise as S.

It has been found by Experiment, that the Air is an elastic Fluid, whose Density and elastic Force are, each of them, proportional to the Force which compresses it; and that the Force compressing a given Quantity of Air, is inverſly as the Space it poſſeſſes by Virtue of that Force, that is, as $\frac{1}{C^3}$. And therefore, D, E, and $\frac{1}{C^3}$, are proportional to one another in the Air. And their being ſo ſhews, that the Air may be compoſed of minute Particles of Matter of equal Diameters and Denſities, which are placed at equal Diſtances from one another, and which repel one another with Forces reciprocally proportional to the Diſtance of their Centers. And that the Air is really compoſed of ſuch Particles endued with ſuch centrifugal Forces, may be granted, ſince the foregoing Properties are not explicable on any other Suppoſition.

Cor. 2. If an elastic Fluid be compoſed of ſuch Particles endued with ſuch centrifugal Forces, as I have ſuppoſed in
this

this Proposition ; the Diameter of the Particles will be in the subquadruplicate Ratio of the Density of the Fluid in Proportion to its Elasticity ; that is, D will be as $\sqrt[4]{\frac{S}{E}}$.

Cor. 3. If an elastic Fluid be composed of such Particles endued with such centrifugal Forces, as I have supposed in this Proposition ; the Distance of the Centers of the Particles will be as their Diameter, and as the subtriplicate Ratio of their Density in Proportion to the Density of the Fluid taken together ; that is, C will be as $D \times \sqrt[3]{\frac{\Delta}{S}}$.

Cor. 4. If an elastic Fluid be composed of Particles of equal Diameters and Densities, which are endued with such centrifugal Forces as I have supposed in this Proposition ; the Distance of the Centers of the Particles in Proportion to their Diameter, will, by *Cor. 3.* be in the subtriplicate Ratio of the Density of the Par-

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ticles in Proportion to the Density of the Fluid ; that is, $\frac{C}{D}$ will be as $\frac{\Delta}{S}^{\frac{1}{3}}$.

Cor. 5. The subduplicate Ratio of the elastic Force of the Fluid in Proportion to its Density, will be in the inverse duplicate Ratio of the Diameter of the Particles ; that is, $\frac{E}{S}^{\frac{1}{2}}$ will be as $\frac{1}{D^2}$. For, E being as $\frac{S}{D^4}$; $\sqrt{\frac{E}{S}}$ will be as $\frac{1}{D^2}$.

I shall illustrate these Corollaries by Examples.

Exam. 9. It has been found by Experiment, that Water is about 870 times denser than Air ; and consequently, if the Density of Water be denoted by 1, the Density of the Air will be denoted by $\frac{1}{870}$. It has been likewise found by Experiment, that the elastic Force of the Air is proportional to its Density ; and consequently, the elastic Force as well as the Density, that is, E as well as S,

S, will be expressed by $\frac{1}{870}$. D is as $\frac{S}{E}$, by *Cor. 2*: But $\frac{S}{E}$ is as 1: And therefore, D will be as 1.

The Distance of the Centers of the Particles lying next to one another, that is, C, will be as $\frac{\Delta}{S}^{\frac{1}{3}}$, D being 1, by *Cor. 3*; or as $870\Delta^{\frac{1}{3}}$, S being $\frac{1}{870}$. If the Particles of Air be of the same Density as Water, in which Case Δ will be 1; then C will be 9.546, and the Interval of the Particles will be 8.546. And $\frac{C}{D}$ will be 9.546, D being 1. In this Case the Distance of the Centers of the Particles will be between 9 and 10 times, and their Interval between 8 and 9 times, their Diameter. But if the Particles of Air be of the same Density as Earth, as we may reasonably suppose them to be, because true Air arises out of earthy Substances by Heat or Fermentation; then Δ will be 2, and C, which is $870\Delta^{\frac{1}{3}}$, will be 12. Here

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Here the Distance of the Centers of the Particles is 12, and their Interval 11, times their Diameter.

Exam. 2. If an *Æther* be 700000 times more rare, and 700000 times more elastic, than Air at the Surface of the Earth; then S will be the $\frac{1}{700000}$ th part of the Density of the Air, and E will be 700000 times its Elasticity; that is, S and E in this *Æther* will be $\frac{1}{700000} \times \frac{1}{870}$ and $700000 \times \frac{1}{870}$; S and E in the Air being $\frac{1}{870}$, by the last Example. $\frac{S}{E}$ will be $\frac{1}{490000000000}$, and $\frac{S}{E}^{\frac{1}{4}}$ will be $\frac{1}{836.7}$ nearly, which is equal to D. The Diameter therefore of a Particle of this *Æther* will be the $\frac{1}{836.7}$ th part of the Diameter of a Particle of Air, which was shewn to be 1 in the last Example.

If the Particles of this *Æther* be perfectly dense or void of Pores; then their
Density

Density expressed by Δ , will be about 40 times as great as the Density of Water; or will be 40, the Density of Water being 1. For Sir *Isaac Newton* gathered from Experiments, that Gold has more Pores than solid Parts; and consequently, Water, which is near 20 times specifically lighter than Gold, will have about 40 times more Pores than solid Parts. And therefore to make the Particles of this *Æther* perfectly solid or void of Pores, their Density must be 40, the Density of Water being 1. The Distance of the Centers of the Particles, denoted by C, being as $D \times \frac{\Delta^{\frac{1}{3}}}{S}$ by *Cor. 3*; and D being $\frac{1}{836.7}$, and S being $\frac{1}{609000000}$, and Δ being 40; C in this *Æther* will be as $\frac{2899}{836.7}$; and $\frac{C}{D}$ will be as 2899; or the Distance of the Centers of the Particles of this *Æther*, will be 2899 times, and the Interval of the Particles 2898 times, their Diameter.

Exam. 3. If an *Æther* be 800000 times more rare, and 800000 times more elastic,

elastic, than Air at the Surface of the Earth; in which Case, S and E will be

$$\frac{1}{800000} \times \frac{1}{870} \text{ and } 800000 \times \frac{1}{870}; \text{ and } \frac{S}{E}$$

$$\text{will be } \frac{1}{640000000000}, \text{ and } \overline{\frac{S}{E}}^{\frac{1}{4}} \text{ will be}$$

$$\frac{1}{894.43}, \text{ which is equal to D.}$$

If the Particles be perfectly dense, as in the last Example, that is, if Δ be 40, then $\frac{\Delta}{S}$ will be 278400000000, and $\overline{\frac{\Delta}{S}}^{\frac{1}{3}}$ will be 3030.7; and C, which is as $D \times \overline{\frac{\Delta}{S}}^{\frac{1}{3}}$, by Cor. 3, will be as $\frac{3030.7}{894.43}$; and $\frac{C}{D}$ will be as 3030.7. The Distance therefore of the Centers of the Particles of this Æther, will be 3030.7 times, and the Interval of the Particles about 3029.7 times, their Diameter.

Exam. 4. If an Æther be 1000000 times more rare, and 1000000 times more elastic, than Air at the Surface of the Earth; the Diameter of the Particles of this

this *Æther* will be the 1000th Part of the Diameter of the Particles of Air; and the Distance of their Centers will be 3264.8 times, and their Interval 3263.8 times, their Diameter.

SCHOLIUM.

We do not know the Diameter or Thickness of a Particle of Air, but thus much we know, that it must be less than the $\frac{1}{416666}$ th part of an Inch, by the Table in Sir *Isaac Newton's* Optics, p. 206. I shall suppose it to be the $\frac{1}{600000}$ th part of an Inch. And if the Particles of Air be twice as dense as Water, as we may suppose them to be, from their arising out of earthy Substances by Heat or Fermentation; the Distance of their Centers, which is 12 times their Diameter by *Exam. 1.* will be the $\frac{1}{50000}$ th part of an Inch.

The Diameter of the Particles of the *Æther* in the second Example, being
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the $\frac{1}{836.7}$ th part of the Diameter of a Particle of Air, will be the $\frac{1}{502020000}$ th part of an Inch; and the Distance of the Centers of the Particles of this *Æther* being 2899 times their Diameter, will be the $\frac{1}{173170}$ th part of an Inch.

The Diameter of the Particles of the *Æther* in the third Example, being the $\frac{1}{894.43}$ th part of the Diameter of a Particle of Air, will be the $\frac{1}{536658000}$ th part of an Inch; and the Distance of the Centers of the Particles of this *Æther*, will be the $\frac{1}{177073}$ th part of an Inch.

The Diameter of the Particles of the *Æther* in the fourth Example, being the $\frac{1}{1000}$ th part of the Diameter of a Particle of Air, will be the $\frac{1}{600000000}$ part of an Inch; and the Distance of the Centers of its Particles, being 3264.8 times their Diameter,

Diameter, will be the $\frac{1}{183778}$ th part of an Inch.

PROPOSITION II. Problem I.

To explain the Motion of an elastic Fluid excited by a trembling Body, suppose a musical String, or any other trembling Body.

The Parts of the trembling Body, going forwards and returning backwards alternately, will in their Progress urge and propel the Parts of the Fluid lying next to them, and thereby compress and condense them; and afterwards in their Return, will suffer the condensed Parts to recede and expand themselves. The Parts therefore of the Fluid lying next to the trembling Body, will go forwards and return backwards, in like Manner as the Parts of the Body. And as the Parts of the trembling Body agitated these Parts of the Fluid, these Parts agitated with like Tremors, will agitate the Parts lying next to them, and those similarly
 3 agitated

agitated will agitate the Parts beyond them, and so on *in infinitum*. And as the first Parts of the Fluid are condensed in their Progress, and rarefied in their Return; so the other Parts will be condensed as often as they go forwards, and expand themselves as often as they return. And therefore, they will not all go forward together, and all come backwards together; for then their respective Distances would always be the same, and consequently they could not be condensed and rarefied by Turns; but approaching towards one another when they are condensed, and receding from one another when they are rarefied, some of them will go forwards whilst others return, and that alternately *in infinitum*. The Parts which go forwards and are condensed in going, are *Pulses*, by virtue of their progressive Motion, with which they strike Obstacles in their Way; and therefore, successive Pulses will be propagated *in directum* from every trembling Body, and that at about equal Distances from one another, by reason of the equal Intervals of
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of Time, in which the Body excites the several Pulses by its several Vibrations. And although the Parts of the trembling Body go and return according to some certain and determinate Direction, yet the Pulses propagated from thence through the Fluid will dilate themselves laterally, and be propagated from the Body as a Center all round, according to Surfaces almost spherical and concentrical. That these Pulses are propagated not only directly forwards according to the Direction of the Motion of the Parts of the trembling Body, but Sideways also, spreading themselves obliquely into the neighbouring Regions of the Fluid, which otherwise would remain at Rest, as lying out of the Track of their direct Motion, may be thus proved. The neighbouring Fluid, which borders on the Sides or Edges of that Track, being in its natural State of Expansion, will be rarer than the Fluid which makes the Pulses, and denser than the Fluid in the Intervals between them. Consequently the Fluid of the Pulses will expand itself laterally into those Parts

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of the bordering Spaces which are over-against the Pulses ; and those Parts of the bordering Fluid which are over-against the Intervals of the Pulses, will for the same Reason dilate themselves laterally into the Intervals ; and thus the bordering Fluid will become denser over-against the Pulses, and rarer over-against the Intervals ; and so partake of that undulating Motion, which at first was propagated directly from the trembling Body. And as the Fluid which borders immediately upon the Track of direct Motion, owes its Undulations to the Fluid contained in that Track, so it after the same Manner communicates like Undulations to the Fluid lying next beyond it, and that like Undulations to the Fluid beyond it, and so on continually. Of this we have some Example in Waves, which if they be excited by a trembling Finger, do not only go this Way and that Way according to the Direction of the Finger, but in the Manner of concentric Circles surround the Finger, and are propagated on all Sides. For the Gravity of the

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Waves

Waves supplies the Place of an elastic Force. All that remains, in order clearly to understand the Nature of this Motion of the Parts of an elastic Fluid caused by a trembling Body, is more particularly to shew the Nature of the Condensation and Rarefaction of the Parts. Since the Parts of the Fluid go forwards and return backwards with Motions like that of a vibrating String, they will be accelerated through one half of their Progress, and retarded through the other; and in coming back, they will be accelerated through the first half of their Return, and retarded through the second. In consequence of these Accelerations and Retardations, the Condensation of the Parts will increase continually through the first half of their Progress, and continually lessen through the second; and the Rarefaction of the Parts will increase continually through the first half of their Return, and continually lessen through the second. Hence the greatest Condensation will be in the Middle of their Progress, and their greatest Rarefaction

in the Middle of their Return. All this will be more clearly conceived by *Fig. 1.* in which A denotes the Magnitude of an exceedingly small given Portion of an elastic Fluid in a quiescent State, and A a the exceedingly small Space it describes, when put into a vibrating Motion. The Magnitude of this Portion of the Fluid will be represented by the lineal Circles in its Progress, and by the prick'd Circles in its Return; consequently, its Density, which increases as its Magnitude lessens, and lessens as that increases, will increase through the first half of its Progress, and lessen through the second; and will lessen through the first half of its Return, and increase through the second; it will be greatest in the Middle of its Progress, and least in the Middle of its Return; and will be greater through its whole Progress, and less through its whole Return, than it is either at the Beginning or End of the little Space through which it moves, in which two Places it is the same.

Cor.

Cor. 1. Hence it appears, that the Number of Pulses propagated from the trembling Body, is the same with the Number of Vibrations of the Body. For the Particles lying next to the trembling Body, will rest as soon as they return to their first place, and not move afterwards, unless they be propelled by a new Vibration of the Body. And as the Vibrations of the trembling Body lessen continually in their Magnitude, and at last cease; so will the Pulses of the Fluid continually lessen in their Magnitude, and at last vanish on a Cessation of the vibrating Motion of the Body.

Cor. 2. When a vibrating Motion is excited in the *Æther* by a trembling Body, the Condensation of the *Æther* in the Pulses of its Vibrations, lessens continually in receding from the Body, as the Square of the Distance from the Body increases. This is the Case of all Motions propagated from a Center, which

lessen as the Square of the Distance from the Center increases.

Cor. 3. If a Body be placed in an elastic Fluid put into a vibrating Motion by a trembling Body, the *Æther* in the Pulses will be densest on that side of the Body which is nearest to the trembling Body, and rarest on that side of it, which is farthest from the trembling Body.

Cor. 4. If the *Æther* within a Body be put into a vibrating Motion, the Density and elastic Force of the *Æther* in the Pulses of the Vibrations, will both be increased in proportion to the Strength and Vigour of the vibrating Motion. Hence the Parts of the Body will be made to recede, and the Body to swell on the *Æther's* being put into a vibrating Motion.

PROPOSITION III.

If a Motion be excited in an elastic Fluid by the vibrating Motion of a String, or of any other trembling Body; the Velocity wherewith the Pulses will be propagated through the Fluid from the Body considered as a Center, will be in the subduplicate Ratio of the Elasticity of the Fluid directly, and in the subduplicate Ratio of its Density inversely; and it will likewise be in the inverse duplicate Ratio of the Diameter of the Particles of the Fluid; that is, putting V for the Velocity of the Pulses, and retaining the Symbols used in the first Proposition for the Elasticity and Density of the Fluid, and for the Diameter of the Particles of the Fluid, V will be as $\sqrt{\frac{E}{S}}$, and likewise as $\frac{1}{D^2}$.

For from the Nature of the Motion of an elastic Fluid explained in the last Proposition, the Parts of the Fluid begin to move on the least Increase of its elastic

Force caused by the least Increase of its Condensation. And therefore the Pulses are propagated from the Center through the Fluid, by a Force which is not sensibly greater than the elastic Force of the Fluid in its natural and quiescent State. On this Account, the elastic Force of the Fluid in a quiescent State, may without any sensible Error be taken for the Force by whose continued Action the Pulses are propagated. E therefore will express the Force generating the Motion of Propagation. The Motion generated by this Force, and propagated *in directum* on all sides the trembling Body considered as a Center, will from the Laws of Motion, be as the Quantity of Fluid contained in a Cylinder of an exceedingly small given Diameter, and of a Length equal to the Distance from the Center to which the Motion reaches, and the Square of the Velocity, taken together, directly; and as the Length of the Cylinder, which is the Space described, inversely; that is, the Motion generated by this Force, will be as the Density of the Fluid and Square of the
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the Velocity taken together. E therefore will be as $S V V$, and consequently V will be as $\sqrt{\frac{E}{S}}$. But $\sqrt{\frac{E}{S}}$ is as $\frac{1}{D^2}$ by *Cor. 5. Prop. 1.* And therefore V will likewise be as $\frac{1}{D^2}$.

Cor. 1. If the elastic Force of the Fluid be proportional to its Density, the Velocity of the Pulses will be given. For if E be as $S, \frac{E}{S}$ and $\sqrt{\frac{E}{S}}$ and V, will all be expressed by 1; and consequently, be all given. This obtains in our Air, whose elastic Force is proportional to its Density; for all Sounds, whether loud or soft, grave or acute, move through the Air with one and the same Velocity; which is such as carries them at the Rate of 1142 Feet in one second Minute of Time, as has been found by Experiments.

Cor. 2. The Particles of one and the same elastic Fluid having all equal Diameters, the Pulses will all move with the same

same Velocity, and the elastic Force of the Fluid will be proportional to its Density. For D being given, $\frac{1}{D^2}$ will be given; and consequently V will be given, as will $\frac{E}{S}^{\frac{1}{2}}$, and $\frac{E}{S}$. The Velocities of the Pulses will be different in two different elastic Fluids, but in one and the same Fluid, all Pulses, whether strong or weak, will move with the same Velocity.

SECONDLY, I shall shew how this Æther causes an universal Attraction and Gravity.

PROPOSITION IV.

If a subtile Æther, such as is described in one or other of the foregoing Examples, be expanded through the Universe, and be supposed at first to be of the same Density every where; and if every Body, and the Æther lying next to it on all Sides, endeavour to recede from each other with a Force, which is as the Quantity of Matter
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in the Body, and the Density of the surrounding Æther, taken together ; I say, that the Æther, by virtue of this Power, which I shall call a repulsive Power, will lose its uniform Density, and become denser and denser in receding from the Body ; and that the Increment of its Density at any Distance from the Center of Gravity of the Body, will be as the Quantity of Matter in the Body directly, and as the Square of that Distance inversely ; that is, putting Q, C, and I, for the Quantity of Matter in the Body, the Distance from its Center of Gravity, and the Increment of the Density of the Æther at that Distance ; I say, that I will be as $\frac{Q}{C^2}$.

For the Force, with which the Body and the Æther lying next to it on all Sides, endeavour to recede from each other, being by Supposition as the Quantity of Matter in the Body and the Density of the surrounding Æther, taken together ; and the Density of the Æther being supposed to be at first the same every where ; and,
con-

consequently, being given, the Force, by which the Body and the *Æther* lying next to it all round will endeavour to recede from each other, will be as the Quantity of Matter in the Body; that is as Q . By this Force the *Æther* will be made to recede from the Body, and thereby lose its uniform Density; it will be rarer at the Surface of the Body, than at a small Distance from it, and rarer there than at a greater Distance, and so will continually grow less and less rare, or, in other Words, more and more dense, *in infinitum*. And the Increment, or Increase of Density, like the Effects of all Powers which are propagated from a Center, will grow less and less, as the Square of the Distance from the Center of Gravity of the Body increaseth. And therefore in receding from the Center of Gravity of the Body, the Increment of the Density of the *Æther* will be as the Quantity of Matter in the Body directly, and as the Square of the Distance from its Center of Gravity inversely; that is, I will be as $\frac{Q}{C^2}$.

It is to be observed, that the Increment of the Density of the *Æther* within the Body at any Distance from its Center of Gravity, will not be as the whole Quantity of Matter of the Body *Q* apply'd to the Square of that Distance, but only as so much of the Matter of the Body *Q* as is contained in a similar Body, supposed to be described to that Distance, apply'd to the Square of the Distance. For, supposing the Body *Q* to consist of a Shell and the lesser Body inclosed within it, those Parts of the Shell which are similar and directly opposite with respect to the Center of Gravity, will, by acting on the *Æther* in directly contrary Directions, destroy each other's Effect, and not in the least contribute to increase the Density of the *Æther* at any Part of the Surface of the lesser Body, by *Prop. 73. lib. 1. Princip. Newtoni.* Let *A D E B* be a Globe, whose Center of Gravity coincides with its Center of Magnitude in *C*; and let *a d e b* be a lesser Globe included within the larger and a Part of it, described to the same Center; the Increment of the
Density

Density of the *Æther* at a, will be as the Quantity of Matter in the lesser Globe a d e b, apply'd to the Square of a C; that is, putting δ for the Density of the lesser Globe, as $\frac{C^3 \delta}{C^2} = C$.

Cor. 1. Hence it follows, that the *Æther* is rarer in Bodies than in empty Spaces without them; that it is rarer in smaller empty Spaces than in larger; and of consequence, rarer in dense Bodies than in rare Bodies, because dense Bodies have less empty Space within them in proportion to their Magnitudes, than Bodies which are rarer.

Cor. 2. If Q be a Globe of the same Density throughout, the Increment of the Density of the *Æther*, in passing from the Center of the Globe to its Circumference, will increase with the Distance from the Center, which Distance is the Diameter of the lesser Globe; and afterwards in passing on, the Increment of the Density will lessen, as the Square of the Distance from the Center increases.

increases. I will increase as C increases from the Center to the Circumference, and afterwards in passing on, will lessen as C^2 increases. For the Density being given, $\frac{Q}{C^2}$ will be $\frac{C^3}{C^2}$, that is C , from the Center to the Circumference; and in passing on, $\frac{Q}{C^2}$ will lessen as C^2 increases, Q being the same at all Distances beyond the Surface.

Cor. 3. If Q be a Globe whose Density increases or decreases uniformly from the Center to the Circumference, in which Case the Center of Gravity will coincide with the Center of Magnitude; the Increment of the Density of the *Æther* will increase with the Diameter and Density of the lesser Globe taken together, in passing from the Center to the Circumference; and in passing on, it will lessen as the Square of the Distance from the Center increases. If δ denote the Density of the lesser Globe, I will be as C^δ from the Center to the Circumference; and afterwards, I will be as $\frac{Q}{C^2}$

Cor.

Cor. 4. If one Part of the Surface of a Body lie nearer to its Center of Gravity than the other Parts do; the Increment of the Density of the *Æther* will be greater at that Part of the Surface than it will be at any other Part. For the Quantity of Matter being the same, the Increment of the Density of the *Æther* will be inverſly as the Square of the Distance from the Center of Gravity; that is, Q being given, I will be as $\frac{1}{C^2}$. And conſequently I will be greateſt on that Side where C is leaſt.

PROPOSITION V.

If a ſubtile Æther and Bodies act on one another in the Manner ſuppoſed in the laſt Propoſition; the Effect of this Action will be an univerſal Attraction, or a mutual Tendency of all Bodies towards one another: And any two Bodies will tend or gravitate towards each other with a Force or Weight, which is as the Quantity of Matter of the two Bodies taken together directly, and as the

the Square of the Distance of their Centers of Gravity inversely. If Q and q denote the Quantities of Matter of the two Bodies, C the Distance of their Centers of Gravity, and W the Weight of either Body towards the other ; I say, that W will be as $\frac{Qq}{C^2}$.

For it is evident from the State into which the *Æther* is put by the mutual Action between it and Bodies, that by the Action of Q, it will be denser on the remotest than on the nearest Sides of all the Particles of the Body q with respect to Q ; and that by the Action of q, it will be denser on the remotest than on the nearest Sides of all the Particles of the Body Q, with respect to q. Consequently, all the Particles of the Body q, by endeavouring to go from the denser Parts of the *Æther* towards the rarer, will tend towards the Center of Gravity of the Body Q ; and all the Particles of the Body Q, by endeavouring to go from the denser Parts of the *Æther* towards

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the rarer, will tend towards the Center of Gravity of the Body *q*. And each Particle of either Body will tend towards the Center of Gravity of the other, with a Force that is proportional to the Quantity of Matter in the Particle, and the Difference of the Densities of the *Æther* on its two said Sides, taken together : And either Body will tend towards the Center of Gravity of the other, with a Force or Weight that is proportional to the Sum of the Quantities of Matter of all its Particles, and the mean Difference of all the Densities of the *Æther* on their said Sides taken together, that is, to the whole Quantity of Matter in the Body, and the Increment of the Density of the *Æther* at its Center of Gravity, taken together. But the Increment of the Density of the *Æther* at the Center of Gravity of the Body *q*, caused by the Action of *Q*, is as $\frac{Q}{C^3}$, by the last Proposition ; and the Increment of the Density of the *Æther* at the Center of Gravity of the Body *Q*, caused by the Action

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tion of q , is as $\frac{q}{C^2}$, by the same Proposition. And therefore, q will tend towards Q with a Force or Weight which is as $q \times \frac{Q}{C^2}$; and Q will tend towards q with a Force or Weight which is as $Q \times \frac{q}{C^2}$. Consequently, the Weight of each Body towards the other, will be as $\frac{Qq}{C^2}$; that is, W will be as $\frac{Qq}{C^2}$.

Cor. 1. If Q be a great Globe, whose Center of Gravity coincides with the Center of its Magnitude; and if q be a very small Body placed on its Surface, so very small in comparison of Q , as that C may without any sensible Error be considered as equal to the Radius of the Globe; then will the Weight of the Body q , or Force with which it gravitates towards the Globe Q , be as the Diameter and Density of the Globe, and the Quantity of Matter in the small Body q , taken together. For in this Case, C is equal to D the Diameter of the Globe;

D^2

and

and consequently, $\frac{Q q}{C^2}$, will be equal to $\frac{D^3 \Delta q}{D^2}$, that is, equal to $D \Delta q$. Therefore W , which is as $\frac{Q q}{C^2}$, will be as $D \Delta q$.

Cor. 2. The Weights of small Bodies, placed at a given Distance from the Center of a great Globe of a given Diameter, and given Density throughout, will be proportional to their Quantities of Matter. For D , Δ , and C being given, W will be as q .

The Weight of one and the same Body is very nearly the same at all small Distances above the Surface of the Earth. For a Body weighing 8000 Grains at the Surface of the Earth, will weigh above 7999.8 Grains at the Distance of 100 Yards above the Surface; and therefore will not lose the $\frac{1}{5}$ th Part of a Grain in 8000, by being removed from the Surface to that Height above it. But so small a Loss is not to be perceived by the nicest Balance. And therefore, W will be

be as q without any sensible Difference, both at the Surface of the Earth, and at all small Distances above it.

If the Body q placed a little above the Surface of the Earth, descend *in vacuo* through the small Space s , in the Time t , and acquire the Velocity v at the End of the Fall; the Weight of the descending Body, that is, W , will be the Force by whose continued Action this Motion is generated; which Motion is as the Weight into the Time of its acting, that is, as $W t$; or as $q t$, W being as q . Therefore $q t$ will be as $q v$, or as $\frac{q s}{t}$. Hence t will be as v , or as $\frac{s}{t}$; and both t and v will be as $\sqrt{s}$. These are the Laws of Bodies descending *in vacuo* at the Surface of the Earth, which have been proved to be true by Experiments; and their being true, proves that at and near the Surface of the Earth the Weights of Bodies are proportional to their Quantities of Matter, as they ought to be by this Corollary.

A Dissertation on the Æther

Cor. 3. The Weight of a given Corpuscle placed at the Surface of a great Globe, of a given Density throughout, will be as the Diameter of the Globe; that is, the Weight of the Corpuscle q towards the Globe Q , will be as the Diameter of the Globe, W will be as D . For in this Case Q is as D^3 , Δ being given; and C is equal to D , the Corpuscle bearing no sensible Proportion to the Magnitude of the Globe. And therefore W , the Weight of the Corpuscle towards the great Globe, of q towards Q , will be as $\frac{D^3}{D^2}$, that is, as D .

Cor. 4. The Weight of a given Corpuscle placed at the Surface of a great Globe, whose Center of Gravity coincides with its Center of Magnitude, is as the Diameter and Density of the Globe taken together; that is, the Weight of the Corpuscle q towards the Globe Q , will be as $D \Delta$. For in this Case Q is as $D^3 \Delta$; and C is equal to D , the Corpuscle being indefinitely small with re-

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spect to the Globe. And therefore W the Weight of the Corpuscle towards the great Globe, of q towards Q , will be as $\frac{D^3 \Delta}{D^2}$; that is, as $D \Delta$.

N. B. The Weight of a given Corpuscle towards any Body, measures the Force of Gravity at the Distance at which the Corpuscle is placed. And as Gravity has sometimes been supposed to be caused by Attraction; so the Weight of a given Corpuscle towards any Body, will measure the Force of Attraction of that Body at the Distance at which the Corpuscle is placed.

Cor. 5. The Forces of Attraction or Gravity, at the Surfaces of great Globes of different Diameters and different Densities, whose Centers of Gravity coincide with their Centers of Magnitude, will, in proportion to the Quantities of Matter in the Globes, be in the inverse duplicate Ratio of their Diameters. For the Force of Attraction or Gravity at the Surface of

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a

a great Globe, in the present Case, is as $D \Delta$, by the last Corollary, that is, W is as $D \Delta$; and Q is as $D^3 \Delta$. And therefore, $\frac{W}{Q}$ will be as $\frac{D \Delta}{D^3 \Delta}$; that is, as $\frac{1}{D^2}$.

Hence it appears that Gravity is greater in the Surfaces of small Planets than in those of great ones, in proportion to their Quantities of Matter.

Cor. 6. If Q be a great Globe whose Quantity of Matter is given, and whose Center coincides with its Center of Gravity, and if q be a lesser Globe moving round it in a Circle with an uniform Velocity expressed by V ; the Square of the Time in which the Globe q will move round the Globe Q , which is called its periodical Time, will be as the Cube of the Distance of its Center from the Center of the Globe Q ; that is, putting T for the periodical Time, T will be as C^3 ,

For

For the Globe Q being given, the Weight of the lesser Globe q towards the great Globe Q , will be as $\frac{q}{C^2}$. This Weight is proportional to the Motion generated by it in q towards Q in a given Particle of Time; that is, putting v for the Velocity generated in q towards Q , and s for the Space described in the given Particle of Time, $\frac{q}{C^2}$, will be proportional to q v , and to q s ; and consequently $\frac{1}{C^2}$ will be as v , and as s . But s is the versed Sine of the small Arch of the circular Orbit described by q in the given Particle of Time, which versed Sine, from the Nature and Greatness of the Circle and Smallness of the Arch is, without any sensible Error, equal to the Square of the said Arch apply'd to the Diameter or Semidiameter of the said Orbit; that is, putting A for the Arch, s is proportional to $\frac{A^2}{C}$. The Velocity of q moving in its Orbit being uniform, the Times of describing the little Arch, and the whole Periphery

Periphery of the Orbit, will be as the little Arch and the whole Periphery, or as the little Arch and Radius of the Orbit, the Periphery being as its Radius; that is, r will be to T , as A is to C ; whence A will be equal to $\frac{C}{T}$, and A^2 equal to $\frac{C^2}{T^2}$. Let $\frac{C^2}{T^2}$ be substituted instead of A^2 in the foregoing Expression $\frac{A^2}{C}$, and then $\frac{C}{T^2}$ will be proportional to s .

And *ex æquo*, $\frac{1}{C^2}$ will be proportional to $\frac{C}{T^2}$; and T^2 will be as C^3 ; or the Square of the periodic Time, will be as the Cube of the Distance of the revolving Globe q from the Center of the Globe Q about which it revolves; which was to be proved.

That the Squares of the periodical Times of the primary Planets moving round the Sun, and of the secondary Planets moving round the primary ones, are proportional to the Cubes of their Distances

stances from the Center of the Body about which they revolve, has been found to be true by Astronomical Observations.

Cor. 7. The Velocities with which the Planets revolve in their Orbits, are in the reciprocal subduplicate Ratio of the Distance of their Centers from the Center of the Globe about which they move ; that is, V is as $\frac{1}{\sqrt{C}}$. For the Velocity is as the Periphery of the Orbit apply'd to the periodical Time, or as the Radius of the Orbit, which is as the Periphery, apply'd to the periodical Time ; that is, V is as $\frac{C}{T}$. But T^2 is as C^3 by the last Corollary ; and consequently, T is as $C \sqrt{C}$. And therefore, V is as $\frac{C}{C \sqrt{C}}$, that is, as $\frac{1}{\sqrt{C}}$.

Cor. 8. The Weights of equal Bodies revolving about one and the same Planet in Circles, will be as the Diameters of the Circles directly, and as the Squares of
of

of their periodic Times inverſly. For Q and q being given, W , the Weight of q towards Q , will be as $\frac{1}{C^2}$, or as $\frac{C}{C^3}$. But C^3 is as T^2 , by *Cor. 6*. And therefore W will be as $\frac{C}{T^2}$.

Cor. 9. The Quantities of Matter in the ſeveral Planets, will be as the Weights of equal Bodies placed beyond the Surfaces of the Planets at equal Diſtances from their Centers. For q and C being given, Q will be as W .

Cor. 10. The Denſities of the Planets, ſuppoſing their Centers of Gravity to coincide with their Centers of Magnitude, will be as the Weights of a ſmall given Body placed at their Surfaces directly, and as their Diameters inverſly.

I have exhibited the laſt Corollaries in Numbers from Sir *Iſaac Newton*, in the two following Tables.

The First Table exhibits the periodical Times in Days and decimal Parts; the Proportions of their mean Distances from the Sun; and their mean Velocities wherewith they revolve round their Orbits, expressed by the *English* Miles described in one Second Minute of Time.

The Second Table exhibits the Proportions of the Diameters, Densities, Quantities of Matter, and Weights of equal Bodies at the Surfaces of the Sun, Jupiter, Saturn, Earth, and the Moon.

T A B L E I.

Planets.	Saturn.	Jupiter.	Mars.	Earth.	Venus.	Mercury.
Periodical Times	10759.275	4333.514	686.9785	365.2565	224.6176	87.9692
Mean Distances	954006	520096	152369	100000	72333	38710
Mean Velocities	5.0133	6.7894	12.5429	15.4855	18.1722	24.8553

T A B L E II.

Globes.	Sun.	Jupiter.	Saturn.	Earth.	Moon.
Diameters	10000	997	791	109	29.863
Densities	100	94 $\frac{1}{2}$	67	400	489
Weights of equal Bodies	10000	943	529	435	145
Matter in the Globes	1	1	1	1	1
		1067	3021	169282	6735392

Cor. 11. If a given Corpuscle be placed extremely near the Surface of a Globe of a given Density throughout; the little Space it will describe towards the Globe in a given Particle of Time, will be as the Diameter of the Globe, that is, s will be as D . For the Weight of the given Corpuscle towards the Globe, will be as the Diameter of the Globe, that is, W will be as D , by Cor. 3. Therefore D will express the Force generating the Motion in the given Corpuscle towards the Globe Q , and will be proportional to the Motion generated in the given Particle of Time. But the Motion generated will be as the Space described, the Corpuscle and Time being both given. And therefore s will be as D .

The Diameter of the Earth being about 7930 *English* Miles, or 41870400 *English* Feet, the Space described by the Force of Gravity at the Surface of the Earth in one second Minute of Time, will be as the Radius of the Earth, which

which is 20935200 Feet. And the Space described by the Force of Gravity, or by the Gravity of a given Corpuscle, at the Surface of a Globe of the same Density with the Earth, and one Foot in Diameter, will be as $\frac{1}{2}$ Foot, that being the Radius of the little Globe. Consequently, the first Space will be to the second, as 20935200 is to $\frac{1}{2}$, or as 41870400 is to 1. At the Surface of the Earth, Bodies fall *in vacuo* 193 $\frac{1}{3}$ Inches in one second Minute of Time. And therefore at the Surface of the small Globe, a Corpuscle would fall by the Force of Gravity the $\frac{1}{216571}$ ft part of an Inch in the same Time. For 193 $\frac{1}{3}$ is to 41870400; as the Space described at the Surface of the small Globe in one Second, is to 1; whence that Space will be equal to the $\frac{1}{216571}$ ft part of an Inch.

Hence it appears, that the Motions caused by Gravity will be exceedingly slow in the minute Particles of Matter. For if the Velocity generated by the
Force

Force of Gravity at the Surface of a Globe homogeneous with the Earth, and one Foot in Diameter, be so very slow, as not to carry a Corpuscle above the $\frac{1}{216571}$ ft part of an Inch in one second Minute of Time, or one Inch in about 30 Hours; it must be vastly slower at the Surfaces of minute Particles of Matter. And therefore the Force of Gravity cannot be the Cause of the violent Motions of those Particles in Fermentation.

Cor. 12. If a given Corpuscle be placed, first at the Surface of a given Globe, and afterwards at a Semi-diameter's Distance from the Surface of the Globe, and be supposed in each Place to describe a very small given Space by the Attraction of the Globe, or its Effect on the *Æther*; the Times of describing this small given Space in these two Places, will be as their Distances from the Center of the Globe. For the Globe, the Corpuscle, and the little Space described,
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being

being all given, $\frac{1}{C^2}$ will be as $\frac{1}{t^2}$; and consequently t will be as C .

The Times of a Corpuscle's describing the same little Space by the Force of Gravity, at the Surface of a great Globe, and at a Semi-diameter's Distance above the Surface, will be as 1 and 2. At the Surface of the Earth, Bodies fall *in vacuo* 16 Feet in one second of Time; and at the Distance of a Semi-diameter from the Surface, they will fall through the same Space in two Seconds; and so on.

Cor. 13. Beyond the Surface of a given Globe, whose Center coincides with its Center of Gravity, the Space described in a given Particle of Time by a given Corpuscle falling towards the Globe freely and without Resistance, will be inversely as the Square of its Distance from the Center of the Globe; that is, s will be as $\frac{1}{C^2}$. For the Weight of the Corpuscle q towards the Globe Q , being as

$$\frac{Qq}{C^2},$$

$\frac{Qq}{C^2}$, will be as $\frac{1}{C^2}$, because Q and q are given. But the Motion generated in the Corpuscle by this Weight in a given Particle of Time, will be as the Space described in that Time, that is, $\frac{1}{C^2}$ will be as s .

The Center of the Moon is distant from the Center of the Earth about 60 Semi-diameters of the Earth; consequently a given Corpuscle being placed, first at the Surface of the Earth, and afterwards at the Distance of the Center of the Moon, will in a given Particle of Time descend towards the Earth through Spaces which are as 1, and $\frac{1}{60 \times 60}$, or as 3600 and 1. But at the Surface of the Earth, the Corpuscle would fall *in vacuo* $193 \frac{1}{3}$ Inches in 1'. And therefore, when placed at the Distance of the Center of the Moon, it would fall *in vacuo* 0.0537th Part of an Inch in the same Time; for 3600 is to 1, as $193 \frac{1}{3}$ is to 0.0537. The Number 0.0537, is the versed Sine

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of the Arch described by the Moon in its Orbit in $1'$; the Semi-diameter of the Earth being 3965 *English* Miles, and the Time of the Moon's moving round its Orbit, being 27 Days, 7 Hours, and 43 Minutes; that is, 2360580 Seconds.

The Diameter of the Earth being 7930 *English* Miles, the Diameter of the Moon's Orbit, which is 60 Times as great, will be 475800, and its Periphery 1494012 *English* Miles. This Periphery being described in 2360580", the Arch described in $1'$ will be the 0.6329th Part of an *English* Mile; and the Square of this Arch divided by the Diameter of the Orbit, will give 0.0000009259th Part of a Mile, or 0.0578 Inches for the versed Sine of the Arch, which is nearly the same as was found above.

Cor. 14. The Weight of a small given Body revolving in a Circle about a great Globe whose Center coincides with its Center of Gravity, will be as the Quantity of Matter in the Globe, and the Radius

dius of the Orbit taken together directly, and as the Square of the periodic Time inverſly ; that is, W will be as $\frac{QC}{T^2}$. For q being given, W will be as $\frac{Q}{C^2}$, or as $\frac{QC}{C^3}$, or as $\frac{QC}{T^2}$, T^2 being as C^3 , by *Cor.* 6.

Cor. 15. The Weight of a given Corpufcle will be greater at the Surface of a Globe, than at any other Diſtance from its Center. If the Globe be homogeneous, the Weight of the given Corpufcle will increaſe with the Diſtance in paſſing from the Center of the Globe to its Surface ; and afterwards in paſſing on, its Weight will leſſen as the Square of the Diſtance from the Center increaſes.

If $A D B$, *Fig.* 3. be a Globe of uniform denſe Matter, if the Radius $C D$ be produced to K , if perpendicular to $C K$ from the Points E and D be drawn $E F$ and $D G$ cutting the Line $C G$ in F and G , and if from any Point H in the

E 3 Line

Line C K without the Globe be drawn H I perpendicular to C K, of such a Length that $\frac{H I}{D G}$ shall be equal to $\frac{C D^2}{C H^2}$; then will the Weight of a given Corpufcle placed at the Points E, D, H, be as the Lines E F, D G, H I, or as C E, C D, $D G \times \frac{C D^2}{C H^2}$. If C E, C D, C H be as the Numbers 1, 2, 4, the Weights of a given Corpufcle at the Points E, D, H, will be as the Numbers 1, 2, $\frac{1}{2}$.

SCHOLIUM.

Having fhewn how the *Æther* caufes an univerfal Attraction and Gravity, I fhall in this Scholium fhew how it caufes fome other Phænomena, not explicable by any other Caufe.

1. If a fmall Pipe of Glafs be dipped at one End into ftagnating Water, as in *Fig. 4.* the Water will rife up within the Pipe to a Height, which will be reciprocally proportional to the Diameter of the Pipe; and both in its Afcent and after it

has arrived to its utmost Height, its Surface will be concave. The Water will rise up within the Pipe from the *Æther's* being denser without the Pipe than within it, by *Cor. 1. Prop. 4.* For the Water in the Vessel will recede from the denser Part of the *Æther* towards the rarer; and of consequence, will sink in the Vessel, and rise in the Pipe. And it will rise so high, till the Weight of the Column in the Pipe above the Surface of the stagnating Water, becomes equal to the Force which raises and suspends it; which Force is proportional to the Difference of the Densities of the *Æther* without the Pipe and within it, multiply'd into the Orifice, or Square of the Diameter of the Pipe. If I denote that Difference, $I D^2$ will express the Force that suspends the Column, and consequently will be equal to the Weight of the Column; that is, $I D^2$ will be equal to the Weight of $H D^2$, and I will be as H : But from Experiment H is as $\frac{1}{D}$. And therefore I will be as $\frac{1}{D}$, that is,

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the Difference of the Densities of the *Æther* without the Pipe and within it, will increase as the Diameter of the Pipe lessens, and lessen as that increases. The Action of the Pipe on the *Æther* within it, grows stronger when its Sides are brought nearer together by a Diminution of its Diameter; and thereby it increases the Rarity of the *Æther* within the Pipe, and makes the Difference of its Density without the Pipe and within it to be in the reciprocal Ratio of the Diameter of the Pipe.

a b, the Surface of the ascending and suspended Column of Water, will be concave. For Glass being denser than Water, the *Æther* will be rarer in the Sides of the Glass Pipe than it is in the Column of Water; and it will be rarer in those Parts of the Column which are contiguous to the Glass, than in Parts more remote, and nearer to the Axis of the Column. Consequently, the superficial Parts of the Column, by moving from the denser Parts of the *Æther* towards

wards the rarer, from the Middle of the Column towards the Sides of the Glass, will rise up at the Sides, and make the Surface of the Column to be concave.

2. If a Column of Mercury be kept suspended in a Glass Pipe, as in the Barometer ; c d, the Surface of the suspended Column, in *Fig. 5*, will be convex. For Mercury being much denser than Glass, the *Æther* will be much rarer in the Column of Mercury, than it is in the Sides of the Pipe. Consequently, the superficial Parts of the Column, by receding from the denser Parts of the *Æther* towards the rarer, from the Sides of the Glass towards the Middle of the Column, will cause the Mercury to rise in the Middle of the Surface, and of Consequence make the Surface to be convex.

3. If two plane polished Plates of Glass be laid together, so that their Sides be parallel, and at a very small Distance from one another, and then their lower Edges be dipp'd into Water, the Water will rise up between them. And the
Height

Height to which it will rise, will be reciprocally proportional to the Distance of the Glasses very nearly. The Water will rise up between the Plates, from the *Æther's* being denser without the Glasses than it is between them, by *Cor. 1. Prop. 4.* For the Water in the Vessel will recede from the denser Part of the *Æther* towards the rarer ; and consequently will sink in the Vessel, and rise up between the Glasses. If D denote the Distance of the Glasses, L their Length, and H the Height to which the Water rises up between them ; the Weight of the suspended Column will be expressed by $D L H$. The Force sustaining the Column must be equal to its Weight. But the Force sustaining the Column, is as the Difference of the Densities of the *Æther* without the Glasses, and between them, multiply'd into the Base of the Column, that is, the Force sustaining the Column is as $I D L$, I denoting that Difference. And therefore the Force expressed by $I D L$, must be proportional to the Weight of the Column

lumn D L H; and I proportional to H. But H is as $\frac{1}{D}$ by Experiment. And consequently I will be as $\frac{1}{D}$; that is, the Difference of the Denfities of the *Æther* without the Glaffes, and between them, will be reciprocally as the Distance of the Glaffes. This can be owing to no other Cause but a Difference in the Force with which the Glaffes act on the *Æther*, when they are placed at different Distances from one another; to their acting more strongly when they are nearer to one another, and more weakly when they are at a greater Distance.

4. If two polished Plates of Glafs, three or four Inches broad, and twenty-four or twenty-five Inches long, be laid, one of them parallel to the Horizon, the other upon the first, so as at one of their Ends to touch one another, and contain an Angle of about 10 or 15 Minutes, and the same be first moistened on their inward Sides with a clean Cloth dipp'd into Oil of Oranges or Spirit of Turpentine,

tine, and a Drop or two of the Oil or Spirit be let fall on the lower Glafs at the other End ; so soon as the upper Glafs is laid upon the lower, so as to touch it at one End as above, and to touch the Drop at the other End, making with the lower Glafs an Angle of 10 or 15 Minutes ; the Drop will begin to move towards the Concourse of the Glasses, and will continue to move with an accelerated Motion till it arrives at that Concourse of the Glasses. If when the Drop is in Motion you lift up that End of the Glasses where they meet, and towards which the Drop moves, till such Time as the Motion ceases, the Drop being then carried downwards by its Weight as much as upwards by the Force which moves it ; and if you do this when the Drop is at different Distances from the Concourse of the Glasses, you may know the Force by which the Drop is moved at all Distances from that Concourse. This Force, by Experiments of this Kind, has been found to be almost reciprocally in a duplicate Proportion of the Distance of the Middle
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of the Drop from the Concourse of the Glasses. From the Course of the Motion of the Drop, the *Æther* must grow denser and denser from the Concourse of the Glasses to their other End; and this it does by the mutual Action of the Glasses and the *Æther* lying between them. For this Action being greatest at the Concourse of the Glasses, and lessening gradually from thence to their other End; the Rarity of the *Æther* will be greatest, and its Density least at the Concourse; and the Rarity will lessen, and the Density increase from the Concourse of the Glasses to their other End. And the Increment of the Density of the *Æther*, which is the Measure of the Force that moves the Drop, is, from the foregoing Experiments, in the reciprocal duplicate Ratio of the Distance of the Middle of the Drop from the Concourse of the Glasses.

THIRDLY, I shall shew how this *Æther* causes Repulsion and Elasticity.

PRO-

PROPOSITION VI.

If the Æther be denser between Bodies than it is on their outward Sides with respect to one another; those Bodies will repel, and endeavour to recede from, one another.

For since Bodies, by the mutual Action between them and the Æther, always endeavour to recede from the denser Parts of the Æther towards the rarer; and since they attract and endeavour to come together, when the Æther is denser on their outward Sides with respect to one another than it is between them; they must of necessity repel, and endeavour to recede from, one another, when the Æther is denser between them than it is on their outward Sides.

PROPOSITION VII.

*If the Air consist of small Particles of Matter, of equal Diameters and Densities, placed at equal Distances from one another;
and*

and if the repulsive Powers of the Particles do not extend beyond, but terminate in, the Particles lying next to them; this Limitation of the Extent of the repulsive Force, will make the Particles to recede from one another; and the repulsive Power of the Particles will be reciprocally proportional to the Distance of their Centers; and the Elasticity of the Air will be proportional to its Density.

For, from the mutual Action of the Particles of Air and the *Æther* lying between them, and from the Termination of this Action in the Particles lying next to one another by Supposition, the Density of the *Æther* will increase from the Centers of the Particles to the Middle of the Distance between their Centers; and consequently, the *Æther* will be rarer at the Surfaces of the Particles than it is at the Middle of the Distance between them. And therefore the Particles will repel, and endeavour to recede from, one another, by the last Proposition.

The

The Increment of the Density of the *Æther* will increase from the Centers of the Particles to their Surfaces, and from their Surfaces will decrease to the Middle of the Distance between the Particles ; and therefore the Increment of the Density will be greater at the Surfaces of the Particles than at any other Distance between their Centers. This Increment at the Surfaces of the Particles, is the Measure of the repulsive Power by which the Particles recede from one another ; and is reciprocally proportional to the Distance of the Centers of the Particles. For as the Force of Gravity or Attraction at the Surfaces of Globes, is measured by the Increment of the Density of the *Æther* at the Surfaces of the Globes ; so the Force of Repulsion in the Particles of Air is measured by the Increment of the Density of the *Æther* at the Surfaces of the Particles. And this Increment varies according to the Degree of Force where-with the Particles act on the *Æther* lying between them, which Degree of Force is reciprocally proportional to the Distance
of

of the Centers of the Particles; as may be gathered from what has been said concerning the Cause of the Ascent of Water up small Pipes of Glass, in *Schol. Prop. 5. n. 1.* And therefore the repulsive Powers of the Particles of Air, or the Forces wherewith they will endeavour to recede from one another, will be reciprocally proportional to the Distance of their Centers.

But a Fluid composed of Particles of equal Diameters and Densities placed at equal Distances from one another, which Particles recede from those which lie next to them with a Force reciprocally proportional to the Distance of their Centers, will have its elastic Force proportional to its Density, by *Cor. 1. Prop. 1.* Therefore the Proposition is true.

Cor. 1. Hence it appears that the elastic Force of the *Æther* lodged within the Pores of Bodies, will be increased when the Bodies are condensed, and their Parts are brought nearer together. For as the

F

elastic

elastic Force of the *Æther* lodged between the Particles of Air, is increased on the Air's being condensed, and its Particles being brought nearer together; so will its Force be increased in other Bodies, as often as they are condensed, and their Parts are brought nearer together.

Cor. 2. When the Parts of a Body are brought nearer together without any Sliding of the Parts, and of consequence the elastic Force of the *Æther* is increased between those Parts by the last Corollary; this increased Force of the *Æther*, as soon as the Force which brought the Parts of the Body nearer together, ceases to act, will make the Parts of the Body to recede from one another, and restore the Body to its former Figure. Such a Body is said to be perfectly elastic.

I shall illustrate this Corollary by Examples.

Exam.

Exam. 1. If a straight Rod of Steel, of Spring Temper, be bent into the Form of a Bow, the Particles in the concave Part of the Rod will be brought nearer together, and those in the convex Part will be removed farther asunder, than they were before the Rod was bent. And consequently, the elastic Force of the *Æther* lying between the Parts, will be increased in the concave Side, and lessened in the convex Side of the Rod; and this will necessarily restore the Rod to its straight Figure, when the Force that bent it is removed.

Exam. 2. If two Ivory Balls strike upon one another, the Parts of each will bend inwards by the Force of the Stroke, and be brought nearer together at that Part where they touch. Consequently the elastic Force of the *Æther* within the Pores of the condensed Parts will be increased, and the increased elastic Force, the very Instant the Force of the Stroke is over, will press the Parts outwards, and by the Action make the Balls to recover

their Figure, and in recovering their Figure, to fly from one another.

Another Cause of Repulsion is a vibrating Motion of the *Æther*. But I shall defer the Consideration of this Cause, till I come to the Article of Heat, and the Rarefaction of Bodies by Heat.

FOURTHLY, I shall shew how this *Æther* causes the principal Phænomena of Light, namely, its Emission, Refraction, Reflexion, Inflexion, and Fits of easy Transmission and easy Reflexion.

LEMMA.

If a Force act continually and uniformly on a Body during the Time of its moving through a certain Space; the Force in proportion to the Quantity of Matter in the Body, will be as the Velocity generated in proportion to the Time, or as the Square of the Velocity generated in proportion to the Space

Space described, or as the Space described in proportion to the Square of the Time.

If F denote the Force, Q the Quantity of Matter in the Body, V the Velocity generated in the Body, S the Space described, and T the Time in which the Body moves through the Space S, and acquires the Ve-

locity V ; I say, that $\frac{F}{Q}$ will be as $\frac{V}{T}$, or as $\frac{V V}{S}$, or as $\frac{S}{T T}$.

For, since the Force acts continually and with the same Degree of Strength during the Time T, the Force and Time of its acting taken together, will be as the Motion generated in that Time, that is, F T will be as Q V ; and consequently, $\frac{F}{Q}$ will be as $\frac{V}{T}$. But from the Nature of this Motion, T is as $\frac{S}{V}$, and V as $\frac{S}{T}$. And therefore by substituting these Values of T and V in the Expression $\frac{V}{T}$, $\frac{F}{Q}$ will be as $\frac{V V}{S}$, or as $\frac{S}{T T}$. The Lemma therefore is true.

A Dissertation on the Æther

Cor. 1. If the Quantity of Matter in the Body and Space described, be both given, the Velocity generated will be in the direct subduplicate Ratio, and the Time of the Motion in the inverse subduplicate Ratio of the moving Force. If Q and S be both given, V will be as $\sqrt{F}$, and T as $\frac{1}{\sqrt{F}}$.

Cor. 2. If the Space described be given, the Force, in Proportion to the Quantity of Matter in the Body, will be as the Square of the Velocity generated directly, or as the Square of the Time of the Motion inverfly. If S be given, $\frac{F}{Q}$ will be as $V V$, or as $\frac{1}{T T}$.

Cor. 3. If the moving Force and Space described, be both given; the Velocity generated will be in the inverse subduplicate Ratio, and the Time in the direct subduplicate Ratio, of the Quantity of Matter in the Body. If F and S be given, V will be as $\frac{1}{\sqrt{Q}}$, and T will be as $\sqrt{Q}$.

Cor.

Cor. 4. If the Velocity generated increase with the Time of the Motion, the Force will be proportional to the Quantity of Matter in the Body. If V be as T , F will be as Q .

Cor. 5. If the Square of the Time be reciprocally as the Space described, the Force in Proportion to the Quantity of Matter in the Body, will be as the Square of the Space described. If T^2 be as $\frac{1}{S}$, $\frac{F}{Q}$ will be as $S S$.

Cor. 6. If the Time of the Motion be given, the moving Force, in Proportion to the Quantity of Matter in the Body moved, will be as the Velocity generated, or as the Space described, in that Time. If T be given, $\frac{F}{Q}$ will be as V , or as S .

Cor. 7. If the Space described, and Time of the Motion, be both given; the moving Force will be proportional to the

F 4 Quantity

Quantity of Matter in the Body. If S and T be both given, F will be as Q.

Cor. 8. If the moving Force of the Body, be proportional to its Density, the Velocity generated in a given Time, will be reciprocally as the Magnitude of the Body; that is, supposing M to denote the Magnitude of the Body, and Δ its Density, V will be as $\frac{1}{M}$. For F being as Δ by Supposition, and Q being as M Δ , $\frac{F}{Q}$ will be as $\frac{\Delta}{M\Delta} = \frac{1}{M}$: But $\frac{F}{Q}$ is as $\frac{V}{T}$; or as V, T being given: And therefore V will be as $\frac{1}{M}$.

Cor. 9. If the moving Force of the Body be as the Increment of the Density of the Æther at its Surface, and that Increment be proportional to the Density of the Body, or to the Quantity of Light contained in the Body; the Quantity of Light contained in the Body, in Proportion to its whole Quantity of Matter, will be
as

as the Velocity generated by that Increment in a given Particle of Time.

PROPOSITION VIII.

To cause the Emission of a Ray of Light from the Sun, the Æther must act upon the Ray with a Force, which, in proportion to the Quantity of Matter in the Ray, is immensely greater than the Gravity of a Body at the Surface of the Earth is, in proportion to its Quantity of Matter.

The Gravity of a Body at the Surface of the Earth, is proportional to the Quantity of Matter in the Body, by *Cor. 2. Prop. 5.* And therefore the Gravity of a Body, in Proportion to its Quantity of Matter, will be as Unity, that is, $\frac{F}{Q}$ will be as 1, at the Surface of the Earth. The Gravity of a Body at the Surface of the Earth, will make it to fall *in vacuo* about 16 Feet in one Second; whence, S will be 16, and T will be 1'.
But

But $\frac{F}{Q}$ is as $\frac{S}{T^2}$, by the *Lemma*. And therefore, $\frac{F}{Q}$ will be as 16 at the Surface of the Earth.

The Distance of the Sun from the Earth is about 77889520.6 *English* Miles, supposing the Parallax of the Sun to be $10''\frac{1}{2}$. This Distance Light describes, according to Dr. *Bradley's* Theory, in about 8 Minutes and 12 Seconds, that is, in 492". And therefore Light moves from the Sun at the Rate of 158312 *English* Miles, or 835887360 *English* Feet, in 1'. When the Time of Action is given, the Force, in Proportion to the Quantity of Matter in the Body moved, will be as the Space described, by *Cor. 6. Lem.* And therefore, if the Time during which the *Æther* acts on a Ray of Light be 1', $\frac{F}{Q}$ in the Ray, will be to $\frac{F}{Q}$ in a Body at the Surface of the Earth, as 835887360 is to 16; or as 52242941 is to 1. But the Force which generates the Motion in
the

the Ray does not do it by acting uniformly on the Ray during the whole Time of one Second, but only by acting upon it during an exceedingly small Part of that Time. If the Time during which the *Æther* acts on the Ray, be only the $\frac{1}{4375}$ th part of one Second, then 52242941 must be increased in the reciprocal duplicate Ratio of $\frac{1}{4375}$, that is, in the reciprocal Ratio of $\frac{1}{19140625}$; which will make $\frac{F}{Q}$ in the Ray to be 10000000000000000 very nearly. On this Supposition of the Time, in which the *Æther* generates the Motion of the Ray by acting uniformly on it, $\frac{F}{Q}$ in the Ray, will be to $\frac{F}{Q}$ in a Body at the Surface of the Earth; very nearly as 10000000000000000, is to 1; as Sir *Isaac Newton* makes it. The Proposition therefore is true.

PROPOSITION IX.

The Force with which the Æther refracts, reflects, or inflects a Ray of Light incident on a Body at the Surface of the Earth, is something greater than the Force of the Æther which emits it from the Sun; and is very nearly proportional to the Density of the Body, excepting that it is greater in unctuous and sulphureous Bodies than in others of the same Density.

For let A B (Fig. 6.) represent the plane Surface of any Body, and I C a Ray incident upon it in C, so that the Angle A C I may be infinitely little; and let C R be the refracted Ray. From a given Point B, and from C the Point of Incidence, perpendicular to the refracting Surface, erect B R and P P. And then if C R represent the Motion of the refracted Ray, and this Motion be distinguished into two Motions, C B and B R, whereof C B is parallel to the refracting Plane, and B R perpendicular to it: C B shall represent
1
the

the Motion of the incident Ray, and BR the Motion generated by the Refraction. The Angle ICP is the Angle of Incidence, and may be looked upon as equal to CBR , IC being infinitely near to AC ; and RCP is the Angle of Refraction, which is equal to the Angle CRB . If CR be made Radius, it will be the Sine of the Angle of Incidence, and CB the Sine of the Angle of Refraction. Therefore putting I and R for the Sines of the Angles of Incidence and Refraction, we shall have $\frac{I}{R} = \frac{CR}{CB}$; and $\frac{IC - R^2}{R^2} = \frac{CR^2 - CB^2}{CB^2} = \frac{BR^2}{CB^2} = BR^2$, supposing CB the Motion of the Ray at its Incidence to be 1. The Proportion of the Sines of Incidence and Refraction of yellow Light, the refracting Body being common Glass, is that of 31 to 20. In this Case therefore I will be 31, and R 20; and $\frac{I^2 - R^2}{R^2}$ will be $1.4025 = BR^2$, CB being 1. And BR the Velocity generated by the refracting Power, will be 1.1842, which is greater than CB , the Velocity of

of the Ray at its Incidence, which is the same, or nearly the same with the Velocity wherewith it is emitted from the same.

Sir *Isaac Newton*, from Experiments, found the refractive Powers of Bodies to be nearly proportional to the Densities of the same Bodies; excepting that unctuous and sulphureous Bodies refract more than others of the same Density.

This great Man has likewise proved, that Bodies reflect and refract Light by one and the same Power, variously exercised in different Circumstances. *Opt. Prop. IX. pag. 244.*

The Cause of the Inflexion of the Rays of Light passing by the Edges of dense Bodies at some Distances from the Bodies, must be the same with the Cause of Refraction and Reflexion; as may appear from the following Queries.

“ Doth not the Refraction of Light
 “ proceed from the different Density of
 “ this

“ this *Ætherial Medium* in different
“ Places, the Light receding always from
“ the denser Parts of the Medium? And
“ is not the Density thereof greater in
“ free and open Spaces void of Air and
“ other grosser Bodies, than within the
“ Pores of Water, Glass, Chrystal, Gems,
“ and other compact Bodies? For when
“ Light passes through Glass or Chrystal,
“ and falling very obliquely upon the
“ farther Surface thereof is totally re-
“ flected, the total Reflexion ought to
“ proceed rather from the Density and
“ Vigour of the Medium without and
“ beyond the Glass, than from the Rarity
“ and Weakness thereof.

“ Doth not this *Ætherial Medium* in
“ passing out of Water, Glass, Chrystal,
“ and other compact and dense Bodies
“ into empty Spaces, grow denser and
“ denser by Degrees, and by that means
“ refract the Rays of Light, not in a
“ Point, but by bending them gradually
“ in curve Lines? And doth not the gra-
“ dual Condensation of this Medium ex-
“ tend

“ tend to some Distance from the Bodies,
 “ and thereby cause the Inflexion of the
 “ Rays of Light, which pass by the
 “ Edges of dense Bodies, at some Distance from the Bodies ?

“ Do not the Rays of Light, which
 “ fall upon Bodies, and are reflected or
 “ refracted, begin to bend before they
 “ arrive at the Bodies ? And are they
 “ not reflected, refracted and inflected by
 “ one and the same Principle, acting variously in various Circumstances ?

The Proposition therefore is true.

Cor. 1. The Proportion of the Sine of Incidence to the Sine of Refraction of a Ray of Light, may be nearly known by knowing the Density of the Body ; that is, $\frac{I}{R}$ may be nearly known, by knowing Δ . For, since $\frac{I^2 - R^2}{R^2}$, or $\frac{I^2}{R^2} - 1$, is nearly proportional to Δ , $\frac{I^2}{R^2}$ will be nearly proportional to $\Delta + 1$; and consequently

quently $\frac{I}{R}$ will be nearly proportional to

$\sqrt{D+1}$

Cor. 2. If Bodies of a given Magnitude contain more or less Light in Proportion to their Densities, excepting that unctuous Bodies contain more Light in Proportion to their Densities, than other Bodies do in Proportion to theirs; then will the Powers whereby Bodies act upon the Rays of Light, to refract, reflect and inflect them, be nearly proportional to the Quantities of Light contained in the Bodies.

That dense Bodies contain more Light in their Composition than rare Bodies, appears from their emitting Lights more copiously, as often as their Parts are sufficiently agitated, whether that Agitation be made by Heat, or by Friction, or Percussion, or Putrefaction, or any other Cause.

And that unctuous and sulphureous Bodies contain more Light in their Composition, than any other Bodies, may be gathered from the stronger Action of Light upon them, whereby they are turned into Fire and Flame; for it is the Strength and Vigour of the Action between Light and sulphureous Bodies, which makes those Bodies take Fire more readily, and burn more vehemently, than other Bodies do.

Now, if we consider the Immenseness of the Power arising from the mutual Action between the *Æther* and Light; that dense Bodies have stronger attractive Powers, and contain more Light than rare Bodies; and that sulphureous Bodies, of all others, have the strongest refractive Powers, and contain most Light; we may safely conclude, that Bodies act upon the *Æther* for increasing its Density, and thereby constituting their refracting and reflecting Powers, chiefly by Virtue of the Light which enters their Composition,

Cor.

Cor. 3. The Strength of the Power wherewith a Body refracts, reflects or inflects a Ray of Light, is measured by the Increment of the Density of the *Æther* at the Surface of the Body; which Increment is the adequate Effect of the mutual Action between the Light contained in the Body, and the *Æther* at its Surface. I say, this Increment is the Measure of the refracting, reflecting or inflecting Power of a Body, as the Increments of the Densities of the *Æther* measure the Forces of Gravity and Repulsion.

The Increase of Density in the *Æther*, caused by the mutual Action between it and the Light contained in Bodies, extends but to a very small Distance from the Bodies; as appears from the Rays of Light passing by the Edges of Bodies, which are not affected so as to be turned out of their rectilineal Course, till they are very near those Edges; as Sir *Isaac Newton* has shewn in the *First Part* of the *Third Book* of his *Optics*.

A Dissertation on the Æther

Cor. 4. If Bodies be composed of several Orders of Particles of different Magnitudes and different Densities; and if the Particles of the first Order, be less and denser than the Particles of the second Order; and the Particles of the second Order, less and denser than those of the third Order; and so on for divers Successions, until the Progression end in the biggest and least dense Particles on which the Operations in Chymistry, and the Colours of Bodies depend, and which, by cohering together, compose Bodies of a sensible Magnitude; then will the refracting Power of the Particles be greater in the Particles of the first Order, than in those of the second; and greater in the Particles of the second Order, than in those of the third; and so will lessen gradually as the Density lessens, and be least in the Particles of the last Order in which the Density is least.

If the Particles of each Order be composed of the smaller Particles of the Order

der below, it; and if the Particles of the first Order be composed of solid Particles, such as have no Pores or empty Spaces within them; and if, in a Particle of each Order, the Intervals or empty Spaces between the Particles which compose it, be to the Magnitude of them all, as x is to 1; then, putting n for the Number of Orders of Particles in a Body, the Density of the Particles of the last Order will be expressed by $\frac{1}{x^n + 1}$. For the Quantity of Matter, in a Particle of the first Order, will, from its component Particles being perfectly solid, be as the Magnitude of them all, that is, as 1; and the Magnitude of the Particle will be as $x + 1$, which is the Sum of the Magnitude of the Intervals, and of the Quantity of Matter in the Particles. But the Density of a Body is as its Quantity of Matter in Proportion to its Magnitude. And therefore, the Density of a Particle of the first Order, will be expressed by $\frac{1}{x+1}$. The Density of a Particle of the second Order,

will be expressed by $\frac{1}{x+1}$; the Density of a Particle of the third Order, by $\frac{1}{x+1}$; and the Density of a Particle of the n Order, by $\frac{1}{x+1}$.

For Instance, if a Body be composed of five Orders of Particles, the Densities of the Particles of these five Orders will be as the Numbers $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{16}, \frac{1}{32}$; and the refractive Powers of the Particles, which are as their Densities, will be as the same Numbers; as will also the Increments of the Density of the Æther at the Surfaces of the Particles, which Increments are the Measures of their refractive Powers, by *Cor. 3.*

Sir *Isaac Newton* has shewn, that nothing more is requisite for producing all the Colours of Bodies, than the several Sizes and Densities of their Particles; and in *Table*, p. 206, has exhibited the Thickness of coloured Plates and Particles

of Air, Water, and Glass, at which each Colour is most intense, in Parts of an Inch divided into 1000000 Parts. That Table I have expressed in another Form in the Table annexed, in which the Numbers under Air, Water, and Glass, are the Parts into which an Inch is divided, and are the Denominators of Fractions, whose common Numerator is 1. For Instance, the Numbers 54545, 72727, and 84507, which stand over-against Bright Red in the second Order, shew that the Thickness of the Plates or Particles of Air, Water, and Glass, exhibiting that Colour, is the $\frac{1}{54545}$ th, the $\frac{1}{72727}$, and the $\frac{1}{84507}$ th Part of an Inch.

The Thickness of Coloured Plates and Particles of

	Air.	Water.	Glass.
Very Black	2000000	2666666	3100000
Black	1000000	1333333	1550000
Beginning of Black	500000	666666	777777
Blue	416666	555555	645161
White	190476	258064	294117
Yellow	140625	187500	217391
Orange	125000	166666	193548
Red	111111	148148	172413
Violet	89552	119403	138888
Indigo	77922	103896	122222
Blue	71428	95238	111111
Green	66115	88236	102941
Yellow	61403	81967	96153
Orange	58064	76923	90000
Bright Red	54545	72727	84507
Scarlet	50847	67796	78947

First Order

Second Order

Purple	47619	63492	73800
Indigo	45248	60344	70175
Blue	42735	56980	66225
Green	39682	52910	61538
Yellow	36842	49180	57142
Red	34483	45977	53435
Blueish Red	31250	41666	48387
Blueish Green	29412	39215	45454
Green	28340	37736	43956
Yellowish Green	27777	37037	43062
Red	24793	33057	38461
Greenish Blue	21739	28986	33707
Red	19047	25397	29412
Greenish Blue	17021	22727	26315
Red	15385	20512	23809
Greenish Blue	14084	18779	21834
Ruddy White	12987	17316	20134

Third Order

Fourth Order

Fifth Order

Sixth Order

Seventh Order

PROPOSITION X.

The Force which emits the Rays of Light from the Sun, acts upon the Rays in proportion to their Quantities of Matter.

For, from the Discoveries of Sir *Isaac Newton*, the Rays of Light are very small Bodies of different Sizes; the least of which make *Violet* the weakest and the darkest of the Colours, and the rest, as they are bigger, make the stronger and more lucid Colours of *Blue*, *Green*, *Yellow*, and *Red*. But all these different Sorts of Rays move from the Sun to the Earth in the same Time, that is, they all describe the same Space in the same Time. And therefore, the Force which emits the Rays of Light from the Sun, must act upon them in proportion to their Quantities of Matter, by *Cor. 7. Lem.*

But tho' the *Æther* acts upon the Rays of Light in proportion to their Quantities of Matter, as it does upon Bodies at the
Surface

Surface of the Earth for causing Gravity ; yet the Strength of the Action between the *Æther* and Light is immensely greater than it is between the *Æther* and Bodies at the Surface of the Earth ; which may be owing to the exceeding Smallness of the Particles of Light, when compared with the grosser Particles of Bodies. For since the immense expansive Force of the *Æther*, arises from the Smallness of its Particles ; it may act upon Light, on account of the Smallness of the Particles of Light, with a vastly greater Force than it does upon grosser Bodies.

PROPOSITION XI.

If the Pulses of the Æther move faster than Light, they will put its Rays into Fits of easy Reflexion, and easy Transmissi-
on.

For nothing more is requisite for putting the Rays of Light into Fits of easy Reflexion and easy Transmissiion, than that they be small Bodies, which by impinging on any
reflecting

reflecting or refracting Surface excite Vibrations in the Æther, (as Bodies by Percussion excite Vibrations in the Air) which Vibrations being swifter than the Rays, overtake them successively, and agitate them, so as by turns to increase and decrease their Velocities, and thereby put them into those Fits. When a Ray is in that Part of a Vibration which conspires with its Motion, that is, when the densest Part of a Vibration is behind the Ray, the Ray easily breaks through a refracting Surface; but when it is in the contrary Part of a Vibration, that is, when the densest Part of a Vibration is before the Ray between it and the Surface, it is easily reflected; and by Consequence, every Ray is successively disposed to be easily reflected, or easily transmitted, by every Vibration which overtakes it.

The Rays of Light, in moving from the Sun to the Earth, describe 835887360 *English* Feet in one second Minute of Time, as is shewn in *Prop. 8.*

The

The Vibrations or Pulses of the *Æthers* in the second, third, and fourth *Exam.* of *Prop.* 1; move with Velocities which carry them 799400000, 913600000, and 1142000000 *English* Feet in 1'; the Velocity of the Pulses of the Air being such, as carries them 1142 Feet in the same Time. The Pulses of the first of these *Æthers* move slower than Light; but the Pulses of either of the others move quicker; and therefore may cause the Fits of easy Reflexion and easy Transmission in the Rays of Light.

FIFTHLY, I shall shew how this *Æther* causes Heat, and the Rarefaction of Bodies by Heat.

PROPOSITION XII.

Heat in Bodies consists in a vibrating Motion of their Parts, excited by a vibrating Motion of the Æther within the Bodies.

For

For, as all Bodies by Percussion excite Vibrations in the Air, and Vibrations in the Air cause a vibrating Motion in Bodies standing in their Way; so the Rays of Light, by impinging on the *Æther* at the Surfaces of Bodies, excite Vibrations in the *Æther*, which Vibrations being propagated into the Bodies, agitate their solid Parts, and put them into a vibrating Motion. But Bodies grow hot by the Rays of Light falling copiously upon them, as appears from their growing hot, when exposed to the Light of the Summer Sun, or to Light congregated by a burning Glass: And they likewise grow hot, whenever the *Æther* within them is put into a strong vibrating Motion by an Agitation of the Parts of the Body, whether that Agitation be made by Friction, Percussion, Fermentation, or any other Cause. And therefore, Heat in Bodies consists in a vibrating Motion of their Parts, excited by a vibrating Motion of the *Æther* within the Bodies.

Cor. I. The Degree of Heat in a Body, is proportional to the Strength of the vibrating Motion of the *Æther* between its Parts; and the Strength of that Motion, is proportional to the Degree of Condensation of the *Æther* in the Pulses of its Vibrations.

PROPOSITION XIII.

Bodies rarefy by Heat; and the Rarefaction of a Body by Heat, setting aside all external Compression of the Body, will be directly as the Degree of Heat in the Body, and inverſly as the Strength of the Cohesion of its Parts. If R denote the Rarefaction of a Body by Heat, H the Degree of Heat in the Body, and C the Strength of the Cohesion of its Parts; then, ſetting aſide all external Compression, R will be as $\frac{H}{C}$.

For both the Density and elastic Force of the *Æther* are greater in the Pulses of its Vibrations, than they are when the *Æther* is in a quiſcent State, by *Prop. 2* ;
and

and when a vibrating Motion is excited in the *Æther* within Bodies, and is thence propagated to the *Æther* without them, both the Density and elastic Force of the *Æther* will be greater in the Pulses within the Bodies, than in those without them; the vibrating Motion of the *Æther* being stronger in Bodies than in empty Spaces, from the strong and mutual Action between the *Æther*, and the Light contained in Bodies. But Bodies from the mutual Action between them and the *Æther*, always recede from the denser Parts of the *Æther* towards the rarer. And therefore, the Parts of Bodies, in receding from the denser Pulses towards the rarer, will move outwards, and thereby cause the Bodies to rarefy and swell.

If the Strength of the Cohesion of the Parts of a Body be given, as it will be in one and the same Body, setting aside external Compression, the Rarefaction of the Body will be proportional to the Strength and Vigour of the vibrating Motion of the *Æther* between
the

the Parts of the Body, that is, proportional to its Degree of Heat, by *Cor. Prop. 12*: And if the Degree of Heat in the Body be given, the Rarefaction of the Body, by that Degree of Heat, will be greater or less, as the Strength of the Cohesion of the Parts of the Body is less or greater; that is, it will be reciprocally as the Strength of the Cohesion of the Parts of the Body: And therefore, when neither the Degree of Heat, nor the Strength of the Cohesion of the Parts of a Body is given, the Rarefaction of the Body will be in a Ratio compounded of the direct Ratio of the Degree of Heat, and the inverse Ratio of the Strength of the Cohesion of its Parts; that is, R will be as $\frac{H}{C}$.

Cor. 1. The Degree of Heat, requisite to produce a given Rarefaction of a Body, will, setting aside all external Compression, be proportional to the Strength of the Cohesion of the Parts of the Body, that is, to the Strength of the

H
Cohesion

Cohesion of the Particles of the last Order, or last Composition ; these Particles being the Parts which immediately compose the Body. If R be given, H will be as C.

The Cohesion of the Parts of solid Bodies, is greater than the Cohesion of the Parts of Fluids ; and therefore, solid Bodies will require a greater Degree of Heat than Fluids, to produce the same Degree of Rarefaction.

Cor. 2. If the Degree of Heat in a solid Body, to which the expansive Force of the *Æther* between the Parts of the Body is proportional, be equal to the Force wherewith the Parts of the Body cohere ; that Body, setting aside external Compression, will become fluid, and its Parts, by yielding to a Force impressed, be rendered capable of moving easily amongst themselves ; for, *a Fluid is every Body whose Parts yield to any impressed Force, and by yielding, are easily moved amongst themselves.* If H be equal to C,
R will

R will be such as shall make the solid Body become fluid.

Hence many solid Bodies become fluid by Heat. If the Heat of the Surface of a human Body in its warmest Parts be 12, as it is in Sir *Isaac Newton's Scale of the Degrees of Heat*, the Heat with which Wax melts and becomes fluid, will be 24 ; that with which Tin melts and becomes fluid, will be 72 ; and that wherewith Lead melts and becomes fluid, will be 96 or 97. And if these melted Bodies be suffered to cool, they will grow solid again ; Wax will begin to stiffen and grow solid when its Heat is lessened to $20 \frac{2}{11}$, Tin when its Heat is lessened to 70, and Lead when its Heat is lessened to 95. But it is to be observed, that when solid Bodies are made fluid by Heat, their Fluids are not near so perfect Fluids as Water under a much less Degree of Heat, which is owing to their Parts being much grosser, and cohering more strongly, than those of Water.

Cor. 3. If the Degree of Heat exceed the Cohesion of the Parts of a Body, it will produce such a Degree of Rarefaction, as shall separate the Parts of the Body; which Parts, when they are shaken off from the Body, and get beyond the reach of the Attraction of the Body, and of one another, will recede from the Body, and also from one another. If H be greater than C, R will be such as shall separate the Parts, and make them become elastic.

As the Parts of Fluids are less, and cohere less strongly, than the Parts of solid Bodies; so they will be thrown off before them, and with a less Degree of Heat, according to the following Account of Sir *Isaac Newton*.

“ The Particles of Fluids, which do
“ not cohere too strongly, and are of
“ such a Smallness as renders them most
“ susceptible of those Agitations which
“ keep Liquors in a Fluor, are most easily separated and rarefied into Vapour,
“ and

“ and in the Language of the Chymists,
“ they are volatile, rarefying with an
“ easy Heat, and condensing with Cold.
“ But those which are grosser, and so
“ less susceptible of Agitation, or cohere
“ by a stronger Attraction, are not separated without a stronger Heat, or perhaps not without Fermentation. And
“ these last are the Bodies which Chymists call fixed, and being rarefied by
“ Fermentation, become true permanent
“ Air ; those Particles receding from one
“ another with the greatest Force, and
“ being most difficultly brought together, which upon Contact cohere most
“ strongly.

The Particles of Light enter the composition of all Bodies, and adhere so strongly to them, as not to be separated and shaken off without a great Degree of Heat. For *Fire* is a Body heated so hot, as to emit Light copiously : But Bodies do not emit Light so copiously as to shine and become Fire, till their Heat be much greater than the Heat of boiling Water,

which is 34 by the aforesaid *Scale*. The least Heat with which burning Bodies shine in a dark Night, but not at all in Twilight, is 136, which is four times as great as that of boiling Water; the Heat, wherewith burning Bodies shine in the Twilight, just before the Rising, or after the Setting of the Sun, but not at all, or but very obscurely in broad Day Light, is 161; and the Heat of burning Coals is from 192 to 210, and may be greater if the Fire be large, and be blown with Bellows.

By this account of Heat, and the Rarefaction of Bodies by Heat, it is evident, that a vibrating Motion of the *Æther* which causes Heat, will be another Cause of *Repulsion*; as I said in p. 68.

SIXTHLY, I shall shew how this *Æther* causes muscular Motion and Sensation.

From the Account I have given of
muscular Motion in my *Animal OEconomy*,
 my,

my, it is evident, that that Motion is caused by the *Æther*. But it is not so clear from that Account, how a Swelling of the Membranes causes a Contraction of the fleshy Fibres. This I shall now explain, from some farther Experiments made on animal Fibres.

PROPOSITION XIV.

If an animal Fibre, by a Force acting on it, be increased or lessened, either in Length or Thickness; its Length will be reciprocally proportional to its Diameter; if its Length be increased, its Diameter will be lessened, and if its Length be lessened, its Diameter will be increased, and in the same Proportion. If L and D denote the Length and Diameter of the Fibre, L will be as $\frac{1}{D}$; whenever a Change is made by any Force either in L or D.

First, if an animal Fibre be extended by a Force acting upon it, its Diameter will be lessened in the same Proportion

as its Length is increased ; as will appear from the following Experiment.

Let an unextended Hair be wound about a small Cylinder in contiguous Rings, until the Rings shall have covered a certain Part of the Length of the Cylinder, suppose a Quarter of an Inch ; and afterwards let the same Hair be extended by an appended Weight, and in this extended State be again wound about the Cylinder in contiguous Rings, until the Rings shall have covered the same Part of the Length of the Cylinder ; and it will be found that the Number of Rings will be greater when the Hair is extended than when it is in a natural State. But the Number of Rings multiply'd into the Diameter of the Hair, will be equal to the Length of that Part of the Cylinder which is covered by the Rings, which Length being given, the Number of Rings multiply'd into the Diameter of the Hair, will be a given Quantity, and may on that Account be denoted by 1 ; but the Number of Rings
is

is as the Length of the Hair. And therefore, the Length of the Hair multiply'd into its Diameter, will be a given Quantity, that is, LD will be as 1; and consequently, L will be as $\frac{1}{D}$.

Let the extending Force be removed, and the Hair will return to its former Dimensions, by contracting in Length and swelling in Thickness. For the elastic Force of the *Æther* lodged within the Pores of the Hair, is greater when the Hair is extended, than when it is in a natural State; as is thus proved. The Quantity of Matter in the Hair is the same when the Hair is extended, as it is when it is not extended; and therefore, putting Δ for the Density of the Hair, $D^2 L \Delta$ will be a given Quantity, and on that Account will be as 1; but DL is as 1, by this Experiment; and consequently, $D\Delta$ will be as 1, and Δ will be as $\frac{1}{D}$, or as L ; that is, the Density of the Hair will increase, as its Diameter lessens, or as its Length increases. But

an Increase of Density in the extended Hair, will be attended with an Increase of the elastic Force of the *Æther* lodged within its Pores, by *Cor. 1. Prop. 7*: And the increased elastic Force will gradually swell the Hair, and of consequence contract its Length, 'till it has restored it to its natural Dimensions. And therefore during the Contraction! of the extended Hair, its Length will lessen as its Diameter increases, that is, L will be as $\frac{1}{D}$.

Secondly, I shall shew, that a vibrating Motion of the *Æther* within the Pores of an animal Fibre, raised by Heat, or any other Cause, will increase the Diameter and lessen the Length of the Fibre; so as that the Diameter and Length shall be reciprocally proportional to one another, that is, so as that L shall be as $\frac{1}{D}$. To prove this, I contrived an Instrument consisting of two erect Pillars fix'd perpendicularly on an horizontal plane Board. To the inside
of

of one of the Pillars was fastened a very fine Wire Spring between two and three Inches long, that would bend and yield to the least Force. The upper Part of this Spring was bent so as to be an Index, and point to the Divisions marked on a little Pin, that pass'd through the upper Part of the Pillar to the Distance of about half an Inch from its inside. To this weak Spring was fastened one End of a Hair, and the other End pass'd through a Hole made in the opposite Pillar, and the Hair, when drawn so as to be just straight without being stretch'd, was fastened by a Pegg. This being done, I heated the Hair, and always found by the Index its Length to be lessened. Farther, I observed Hairs to grow straight by Heat, which when placed in the Instrument were crooked from their being of a greater Length. These Experiments shew, that a vibrating Motion of the *Æther* within the Pores of an animal Fibre raised by Heat, lessens the Length of the Fibre. But the Length of an animal Fibre cannot

be lessened by Heat, unless there be an Increase of its Diameter at the same time; it being the Nature of Heat to increase the Magnitudes of solid Bodies. Now Heat, agreeably to its Nature, may increase the Magnitude of a Fibre, and yet lessen its Length, if the Diameter be increased in the same Proportion as the length is lessened, that is, if D be as $\frac{1}{L}$, or $D L$ be as 1. For the Magnitude of the Fibre is as $D^2 L$; and therefore will be as D , if $D L$ be as 1. Consequently, when the Length of a Fibre is lessened by a vibrating Motion of the *Æther* within its Pores caused by Heat or any other Way, we may allow the Diameter to be increased in the same Proportion as the Length is lessened, that is, L to be as $\frac{1}{D}$.

On suffering the Hair to grow cool, I always observed its Length to have been increased, and consequently its Diameter must have been lessened, and that in the same

same Proportion. For if a vibrating Motion of the *Æther* can increase the Diameter, and lessen the Length of a Fibre, so as that they shall be reciprocally proportional to one another; an Abatement of the vibrating Motion, on which the Length of the Fibre increases, will give an Opportunity to the Parts of the Fibre to be brought nearer together by their Attraction, and so will lessen the Diameter in the same Proportion as the Length is increased; that is, will make L to be as $\frac{1}{D}$.

The Proposition therefore is true.

Cor. 1. If a vibrating Motion be raised in the *Æther* contained in the Fibres of the Muscles; the Diameters of all the Fibres will be increased, and their Lengths lessened, by that Motion. But a Contraction of the fleshy Fibres will bring the Parts, to which the Extremities of the Muscles are fastened, nearer to one another. All therefore that

that is necessary to give Animals a Power of moving their own Bodies, is to give them a Power of raising a vibrating Motion in the *Æther* contained within the Fibres of the Muscles. And this Power they have by the Mediation of the Nerves, which are solid uniform Threads arising from that part of the Brain to which the Soul is present, and terminating in the Muscles. For a vibrating Motion, raised by the Power of the Will in the *Æther* contained in that End of a Nerve, which terminates in the Sensorium or place in the Brain to which the Soul is present, will in an Instant be propagated to the Muscles supplied by that Nerve, and raise a like vibrating Motion in all its Fibres, from the great Communication there is between the Nerves and the fleshy Fibres of the Muscles. This account of the Motion of the Muscles, is the same with that given by Sir *Isaac Newton*, in the 24th Query of his *Opticks*, which stands thus,

“ Is not animal Motion performed by
 “ the Vibrations of this Medium (mean-
 “ ing the *Æther*) excited in the Brain by
 “ the Power of the Will, and propagated
 “ from thence through the solid, pellucid
 “ and uniform Capillamenta of the Nerves
 “ into the Muscles, for contracting
 “ and dilating them? I suppose that the
 “ Capillamenta of the Nerves are each of
 “ them solid and uniform, that the vibra-
 “ ting Motion of the *Æthereal* Medium
 “ may be propagated along them from one
 “ End to the other uniformly, and with-
 “ out Interruption: For Obstructions in
 “ the Nerves create Palsies. And that
 “ they may be sufficiently uniform, I
 “ suppose them to be pellucid when
 “ viewed singly, tho’ the Reflexions in
 “ their Cylindrical Surfaces may make
 “ the whole Nerve (composed of many
 “ Capillamenta) appear opaque and white.
 “ For Opacity arises from reflecting Sur-
 “ faces, such as may disturb and interrupt
 “ the Motions of this Medium.

PROPOSITION XV.

The Species of Things are conveyed by vibrating Motions of the Æther through the Nerves of the Organs of Sense into the Sensorium, or that Part of the Brain of Animals, to which the sensitive Substance is present, and are there perceived and beheld by that Substance, by virtue of its Nature and their immediate Presence to it under the Forms of Sensations.

For the Vibrations of this *Æther*, excited in the Bottom of the Eye by the Rays of Light, and propagated through the solid, pellucid and uniform *Capillamenta* of the Nerves into the Place of Sensation, are there perceived and beheld by the sensitive Substance under the Forms of Colours. And the Vibrations of this *Æther*, excited in the auditory Nerves by the Tremors of the Air, and propagated through the solid, pellucid and uniform *Capillamenta* of those Nerves into the Place of Sensation, are there perceived

ceived by the sensitive Substance under the Forms of Sounds. And so of the other Senses.

When the vibrating Motion of the *Æther*, in the solid Parts of the Body, is so strong as to endanger a Solution of Continuity in those Parts, that Motion propagated through the solid and uniform Capillamenta of the Nerves into the Place of Sensation, is there perceived by the sensitive Substance under the Form of Pain. And a more gentle vibrating Motion, such as is agreeable, when conveyed by the Nerves into the Presence of the sensitive Substance, is perceived by it under the Form of Pleasure.

SEVENTHLY, and Lastly, I shall shew how this *Æther* makes the Particles of Bodies to cohere, and causes Fermentation.

PROPOSITION XVI.

The Force with which the Æther causes the Cohesion of the Particles of Bodies, is different from the Force with which it causes Gravity; and the Forces with which the Particles of Bodies cohere, are nearly proportional to the Densities of the Particles.

For the Force of the Æther which causes Gravity, though it gives Bodies mutual Tendencies towards one another, and on that Account may bring them together, and make them to touch, is yet so exceedingly weak in the minute Particles of Matter, as, when they are brought together and touch one another, not to be able to make them cohere with any Degree of Force. The Force of Gravity at the Surface of a globular Particle homogeneal with the Earth, whose Diameter is the $\frac{1}{600000}$ th Part of an Inch, is less than the Force of Gravity at the Surface of the Earth, in the Proportion
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of 1 to 3014668800000000. But this Force is so exceeding small, as not to be able to cause any Cohesion in such Particles, when they touch one another. And therefore, the Force with which the *Æther* makes the Particles of Bodies to cohere, is very different from the Force wherewith it causes Gravity. The Force of Cohesion can be no other than a Force arising from the Particles of Light united with the Particles of Bodies. For as Bodies acquire a Power of refracting and reflecting the Rays of Light from the Light which is united with the Bodies; so the Particles of Bodies, when they touch, acquire a Power of cohering from the Light which is united with the Particles. The Light united with the Particles, causes an Increase of the Density of the *Æther* lying next to them, and the Increments of the Density, when the Particles touch, press them on the Sides opposite to the Places of Contact, and by that Pressure makes the Particles to cohere with Force. The Forces of Cohesion are proportional to the Incre-

ments of the Density of the *Æther* at those Sides of the Particles ; but the Increments of the Density of the *Æther* caused by Light, are nearly proportional to the Densities of the Particles : And therefore the Forces with which the Particles of Bodies cohere, are nearly proportional to the Densities of the Particles. Which was to be proved.

Cor. 1. In the several Orders of Particles of which a Body is composed, the Particles of the first Order, from their being densest, cohere with the strongest Force ; and as the Particles of the following Orders lessen in Density, so they likewise lessen in the Strength of their Cohesion.

Since the Magnitudes of the Particles of the several Orders increase from the first Order to the last, the Force of Cohesion will be strongest in the smallest Particles, and weakest in the largest ; according to what Sir *Isaac Newton* has delivered

livered in the following Words. “ Now
 “ the smallest Particles of Matter may
 “ cohere by the strongest Attractions,
 “ and compose bigger Particles of weaker
 “ Virtue; and many of these may co-
 “ here and compose bigger Particles
 “ whose Virtue is still weaker, and so
 “ on for divers Successions, until the
 “ Progression end in the biggest Particles
 “ on which the Operations in Chymistry,
 “ and the Colours of natural Bodies de-
 “ pend, and which by cohering com-
 “ pose Bodies of a sensible Magnitude.”

Opt. p. 370.

PROPOSITION XVII.

*The Force with which the Æther causes
 Fermentation, is vastly superior to the
 Force with which it causes Gravity; and
 is of the same Nature with the Force
 wherewith it causes the Cohesion of the
 Particles of Bodies.*

That the Force with which the Æther
 causes strong Fermentation, is vastly
 I 3 superior

superior to the Force with which it causes Gravity, will appear from the following Instances. “ When Oil of Vitriol is
“ drawn off from its Weight of Nitre,
“ and from both the Ingredients a compound Spirit of Nitre is distilled,
“ and two Parts of this Spirit are poured
“ on one Part of Oil of Cloves or
“ Caraway Seeds, or of any ponderous
“ Oil of vegetable or animal Substances,
“ or Oil of Turpentine thickened with
“ a little Balsam of Sulphur, the Liquors
“ grow so very hot in mixing as presently
“ to send up a burning Flame. Well
“ rectified Spirit of Wine poured on
“ the same compound Spirit flashes.
“ The gross Body of Sulphur powdered,
“ and with an equal Weight of Iron
“ Filings, and a little Water made into
“ a Paste, acts upon the Iron, and in
“ five or six Hours grows too hot to be
“ touched, and emits a Flame. And
“ sulphureous Steams, which abound in
“ the Air at all times when the Earth is
“ dry, ferment there with nitrous Acids,
“ and sometimes taking Fire cause
“ Lightning

“ Lightning and Thunder, and fiery
 “ Meteors. These Instances shew, that
 “ in strong Fermentations, the Particles
 “ of Bodies which almost rest, are put
 “ into new Motions by a very potent
 “ Principle, which act upon them on-
 “ ly when they approach one another,
 “ and causes them to meet and clash
 “ with great Violence, and grow hot
 “ with the Motion, and dash one ano-
 “ ther to Pieces, and vanish into Air,
 “ and Vapour, and Flame.” And
 that the Force with which the *Æther*
 causes the weaker Fermentations of
 vegetable Juices, is greater than the
 Force wherewith the *Æther* causes Gra-
 vity, appears from the great Force with
 which Liquors are rarefied when in a
 State of Fermentation; which Force is
 so great, as to burst the Vessels in which
 the Liquors are contained, when they
 are full and close stopped.

That the Force with which the *Æther*
 causes Fermentation, is of the same Na-
 ture with the Force wherewith it causes

the Cohesion of the Particles of Bodies, appears from the Nature of the Particles, which are principally concerned in causing Fermentation, namely acid, and unctuous sulphureous Particles. For unctuous sulphureous Bodies contain much Light in their Composition, as appears from their being in a good Measure convertible into Light when set on Fire. And that Acids have their Power from the Light they contain, may appear from the following Considerations. Both Acids and Light attract dense fixed Bodies more than Water; but such Bodies contain more Light in their Composition than Water: They both attract unctuous sulphureous Bodies more strongly than others of the same Density; but those Bodies of all others contain most Light: They both attract Iron more strongly than other Metals; but Iron contains more Sulphur than other Metals: And Acids have their Strength much increased by Fire, from the Particles of Light which they acquire from it. And therefore, acid and sulphureous Particles in causing Fermentation,

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tion, act upon the *Æther* by increasing its Density, and, by the Increments of its Density, they act on one another by virtue of the Light contained in the Particles; therefore, they act on the *Æther* for causing Fermentation, in the same Manner as they act upon it for causing the Cohesion of the Particles of Bodies when they touch one another. Which was to be proved.

Cor. 1. If the moving Force of a Particle, be as the Density of the Particle; the Velocity generated by that Force in an exceedingly small given Particle of Time, will be reciprocally as the Magnitude of the Particle; by *Cor. 8. Prop. 7.*

The Velocities of exceedingly minute Particles moved by Forces in this Proportion, may be so great, as to make the Particles meet and clash with great Violence, and dash one another to Pieces, and vanish into Vapour and Flame.

GENERAL

GENERAL SCHOLIUM.

Having shewn how the *Æther* causes a great Part of the Phænomena of Nature, it may be asked whence this general material Cause has its great Activity and Power. For since its Particles do not touch, and yet repel one another with great Force, there must be some Cause interceding the Particles, which gives them this repulsive Power. This Cause must be either Matter or Spirit, there being nothing in the Universe, which we know of, besides these two. But this Cause cannot be Matter; for Matter is in its own Nature inert, and has not any Activity in itself; and consequently, cannot communicate any Power to the *Æther*. And therefore the Cause, which gives the *Æther* its Activity and Power, must be Spirit.

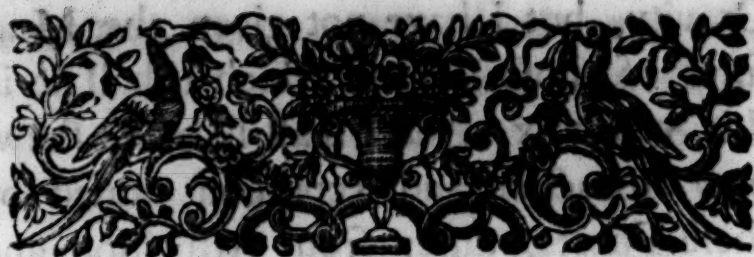
Spirit, which intercedes the Particles of *Æther*, and gives them a repulsive Power,

Power, and ordains and executes the Laws by which *Æther* and Bodies act mutually on one another, must be present in all Parts of Space where there is *Æther*. But, there is *Æther* in all Parts of Space in which we can discover Attraction, Gravity, Light, or any other of the Phænomena, which I have shewn to be caused by an *Æther*: There is an universal Attraction in all Bodies in the solar System; Comets gravitate towards the Sun; there is Light in all the fixed Stars; and if the fixed Stars be Centers of other Systems, as the Sun is the Center of our System, we may reasonably conclude, that all the Phænomena I have mentioned, will be found in the Systems of the fixed Stars, as well as in the solar System. And therefore, as there is every where *Æther*, there must be every where Spirit, in every Part of infinite Space. And the *Æther* being one and the same in all Parts of Space, as we may conclude it to be from Light, being the same every where; the Spirit which gives it Activity,

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and executes its Laws, must be one and the same Spirit every where present in all Parts of Space.

F I N I S.



A N

APPENDIX

TO THE

Dissertation on the *Æther*.

Dec. 1. 1746.

I Have shewn in the *Dissertation*, how the *Æther* causes Gravity by giving Bodies a mutual Tendency to one another. And I have likewise shewn, that the Forces whereby the *Æther* causes the Refraction and Reflection of Light, the Cohesion of the contiguous Particles of Bodies, and Fermentation, are vastly superior

superior to the Force with which it causes Gravity, but I have not given the Measures of those Forces, which I shall do in this Appendix. And I shall likewise shew, how Attraction and Repulsion caused by these Forces, differ from Attraction and Repulsion caused by the Force of *Electricity*.

PROPOSITION I.

The refractive Force of a Globe, whose Center coincides with its Center of Gravity, is measured by the Force of Gravity at its Surface in Proportion to its Diameter; or by a Ratio compounded of the Force of Gravity at the Surface directly, and a Force which is as the Diameter inversely. And the repulsive Force of the Globe, which begins where its refractive Force ends, is measured by the refractive Force of the Globe in Proportion to its Diameter; or by a Ratio compounded of the direct Ratio of its Density, and the reciprocal Ratio of its Diameter. If R denote the refractive Force of the Globe, r its repulsive Force,
D its

D its Diameter, and Δ its Density; then
will *R* be measured by $\frac{D\Delta}{D} = D\Delta \times \frac{1}{D}$;
and *r* be measured by $\frac{\Delta}{D} = \Delta \times \frac{1}{D}$.

The Forces of Bodies to refract and reflect Light, are proportional to the Densities of the same Bodies, except that unctuous and sulphureous Bodies refract more than others of the same Density, by *Prop.* 10. p. 245. of Sir *Isaac Newton's Opticks*. Therefore *R* is proportional to Δ . But Δ is equal to $\frac{D\Delta}{D}$, which is equal to $D\Delta \times \frac{1}{D}$. The Part of the Measure of the refractive Force expressed by $D\Delta$, is the Measure of the Force of Gravity at the Surface of the Globe, by *Cor.* 4. *Prop.* 5. *Dissert.*; and the other Part of the Measure of that Force, expressed by $\frac{1}{D}$, is the Measure of a Force arising from the Light contained in the Globe, which acts on the *Æther* at the Surface with a Degree of Strength that is measured by the Ratio of
the

the Surface of the Globe to its Magnitude, that is, by the reciprocal Ratio of its Diameter. For there can be nothing in the Globe except the Particles of Light it contains, which can any way alter the Force of Gravity, at and to a very small Distance from the Surface, for constituting the refractive Force. Therefore the refractive Force is measured by a Ratio compounded of the Force of Gravity at the Surface, and the Force at the Surface which arises from the Quantity of Light contained in the Globe; that is, R is measured by $D \Delta \times \frac{1}{D}$. The *Æther* is condensed gradually by the joint Action of these two Forces to a small Distance from the Surface, at which Place the Force of the Light ceases; and the *Æther*, notwithstanding the Force of Gravity still continues to act, is rarefied from that Place to a little Distance farther removed from the Globe, where the Density of the rarefied *Æther* becomes the same with the Density caused by the single Force of Gravity. And there the Rarefaction ends,
and

and the *Æther* afterwards, in receding from the Globe, will be condensed by the Force of Gravity acting alone.

The whole repelling Force, arising from the Rarefaction of the *Æther* from the Place where the Action of Light ceases, to the Place where the Rarefaction ends, is as the Density of the Globe in proportion to its Diameter, that is, as

$\frac{A}{D}$. As the Force of Gravity at the Surface of the Globe, changed in the reciprocal Ratio of the Diameter of the Globe, measures the whole refractive Force of the Globe; so the Force of Rarefaction at the End of the refractive Force, changed in the same reciprocal Ratio of the Diameter of the Globe, will measure its whole repulsive Force. For the Condensation and Rarefaction of the *Æther* constituting these Forces, will proceed in the same manner, and be governed by the same Law. But Δ measures the Force of Rarefaction at the Beginning of the repulsive Force: And therefore

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the

the whole repulsive Force denoted by r , will be measured by $\Delta \times \frac{1}{D} = \frac{\Delta}{D}$. Consequently, the Proposition is true.

Cor. 1. The Force of Gravity at the Surface of the Globe, is to the refractive Force of the Globe, as the Diameter of the Globe, is to Unity. $D \Delta . \Delta :: D . 1$.

Cor. 2. The repulsive Force of the Globe is to its refractive Force, as the reciprocal Ratio of the Diameter is to Unity. $\frac{\Delta}{D} . \Delta :: \frac{1}{D} . 1$.

Cor. 3. The Force of Gravity at the Surface of the Globe is to its repulsive Force, as the Square of the Diameter of the Globe, is to Unity. $D \Delta . \frac{\Delta}{D} :: DD . 1$.

Cor. 4. If the Diameter of the Globe be given, the repulsive Force will be equal to the refractive Force. If D be given, $r . R :: \Delta . \Delta$, that is, in a Ratio of Equality.

Cor.

Cor. 5. Hence the *Æther* will be denser where the refractive Force ends, or where the Force arising from the Light contained in the Globe ceases, than it is in any Part of the Space between the Surface of the Globe and the End of the Rarefaction.

Cor. 6. When a Corpuscle is placed between the densest Part of the *Æther* and the Globe, it will be driven towards the Globe with a strong accelerated Motion; and it will be driven from the Globe when it is placed between the densest Part and the End of the Rarefaction. When the Corpuscle moves towards the Globe it is said to be attracted by the Globe, and when it moves from the Globe it is said to be repelled by it. These Motions of Attraction and Repulsion, which are very strong, necessarily happen from the Situation of the Corpuscle with respect to the densest Part of the *Æther* and the Globe. For Bodies always move from the denser Part of this Medium towards the rarer.

Cor. 7. The Increment of the Density of the *Æther* at the Surface of the Globe, caused by the united Forces of Gravity and Light, is very great ; and consequently a Particle touching the Globe, will, by virtue of this Increment, cohere with it very strongly.

Hence the Causes of Cohesion and Fermentation act with great Force in the minute Particles of Bodies ; and with greater Force in smaller Particles, than in Particles which are larger.

PROPOSITION II.

If the Density of the Æther contained in a Body, be reciprocally proportional to the Density of the Body ; then the Quantity of Æther contained in the Body, will be measured by the Magnitude of the Body in Proportion to its Density, or by the Square of its Magnitude in Proportion to its Quantity of Matter. If d denote the Density, and q the Quantity of Æther contained in a Body ; and if Q denote the Quantity of Matter,

Matter, M the Magnitude, and Δ the Density of the Body; I say, that q will be measured by $\frac{M}{\Delta}$, or by $\frac{MM}{Q}$.

For by Supposition, d is as $\frac{1}{\Delta}$; and consequently, M d is as $\frac{M}{\Delta}$, or as $\frac{MM}{Q}$. But M d, is as q. And therefore, q is as $\frac{M}{\Delta}$, or as $\frac{MM}{Q}$.

Cor. 1. If the Magnitude of the Body be given, the Quantity of *Æther* contained in the Body, will be inverſly as its Density, or inverſly as its Quantity of Matter. If M be given, q will be as $\frac{1}{\Delta}$, or as $\frac{1}{Q}$.

Cor. 2. If the Density of the Body be given, the Quantity of *Æther* contained in its Pores will be as the Magnitude of the Body. If Δ be given, q will be as M.

Cor. 3. If the Quantity of Matter in the Body be given ; the Quantity of *Æther* within its Pores, will be as the Magnitude of the Body in Proportion to its Density, or as the Square of its Magnitude. If Q be given, q will be as $\frac{M}{\Delta}$ or as $M M$.

Cor. 4. Hence, by knowing how Bodies are affected as to to their Magnitudes, Densities and Quantities of Matter, by Heat, Cold, Driness and Moisture, we may judge of the Changes made by these Qualities in the Quantities of *Æther* lodged within them. For Instance, the Quantity of *Æther* in a Body will be increased, when the Magnitude of the Body is increased, and its Density lessened, by Heat ; and on the contrary, the Quantity of *Æther* will be lessened, when the Magnitude of the Body is lessened, and its Density increased, by Cold. And the Quantity of *Æther* in a Body whose Magnitude is given, will be increased by Driness and lessened by Moisture ; for
Driness

Dryness lessens and Moisture increases its Quantity of Matter.

Cor. 5. The vibrating Motion of the *Æther* in a Body excited by a given Force, will be stronger or weaker as the *Æther* is denser or rarer. This appears from a vibrating Motion raised in the Air by the Tremors of Bodies for the Production of Sound. For Sound produced by a given Force is stronger or weaker as the Air is more or less dense, as is proved by the Sound of a Bell placed under a Receiver, which grows weaker and weaker on drawing out the Air, as the Density of the Air lessens, and at last is not to be heard, when the Air is exhausted.

General SCHOLIUM.

The refractive and reflective Forces of Bodies are confined within very narrow Limits. The reflective or repulsive Force seldom, if ever, extends to a Distance beyond the Surface of a Body, that can be perceived by Sense. By some Experiments

ments in the first Part of the third Book of the Opticks, the repulsive Force did not extend beyond the 400th Part of an Inch from the Surface. And allowing the Diameter of a Particle of Air to be the 600000th Part of an Inch, as I supposed in *Schol. Prop. 1. Dissert.* and that Air can be rarefied by its elastic Force, so as to take up a Million of Times more Space than it does in the Form of a dense Body, the repulsive Force of a Particle of Air does not extend beyond the 6000th Part of an Inch from its Surface.

The Extent of these Forces of Attraction and Repulsion, is very much enlarged in electrical Bodies by Friction. Without Friction, the Extent of them may be much the same in electrical Bodies as in others, according to the Opinion of Sir *Isaac Newton*, delivered in the following Words, “ The Attractions of Gravity, “ Magnetism, and Electricity, reach to “ very sensible Distances, and so have “ been observed by vulgar Eyes, and “ there may be others, which reach to so “ small

“small Distances as hitherto escape Observation; and perhaps electrical Attraction may reach to such small Distances without being excited by Friction.”

Therefore, to understand how Friction enlarges the natural Extent of the attractive and repulsive Forces of electrical Bodies, we must know the Effects of Friction on Bodies. Now Friction raises a vibrating Motion in the Parts of Bodies, and thereby causes Heat; and Heat increases the expansive Force of the *Æther* lodged within the Bodies, and an Increase of that Force makes it throw off from their Surfaces the more volatile Parts of the Bodies in Vapour and Exhalation. Now the Vapour thrown off from Bodies made electrical by Friction or Communication, from the Quantity of Light it contains, and the Force with which it is thrown off, may make the attractive and repulsive Forces extend to far greater Distances from the Surfaces of those Bodies, than they did before the electrical Virtue was excited. The

The Vapour thrown off from Bodies made electrical by Friction or Communication, passes more easily into dense Bodies than into rare Bodies. For the denser the *Æther* in any Body is, the stronger will its repulsive Force be; and the stronger its repulsive Force is, the more Opposition it will give to the Entrance of the electrick Vapour into that Body. But the *Æther* is denser in rare Bodies than in dense Bodies, by *Cor. 1. Prop. 4. Dissert.* And therefore the electrick Vapour finds an easier Admission into dense Bodies than into rare Bodies. Here it is to be observed, that unctuous and sulphureous Bodies give greater Opposition to the Entrance of the electrick Vapour into them, than other Bodies of the same Density.

If the Density of the *Æther* in a Body be inversly as the Density of the Body, as I supposed it to be in *Prop. 2*; then will the Densities of several Bodies, the Densities of the *Æther* within those Bodies, and the Quantities of their Pores to the Quantities of their solid Parts, be exhibited

bited in the following Table ; in which Table, I found the Proportion of the Pores to the Parts, by this Measure,

$$\frac{41 \cdot 244 \Delta}{\Delta}$$

Sir Isaac Newton from Expe-

$$\frac{41 \cdot 244 - \Delta}{\Delta}$$

riments, concludes Gold to have more Pores than solid Parts ; if the Pores to the solid Parts be as 11 to 10, then, the Density of fine Gold being to the Density of Water, as 19.64 to 1, and Δ denoting the Density of a Body, the Pores to the solid Parts in that Body, will be measured by

$$\frac{41 \cdot 244 \Delta}{\Delta}$$

$$\frac{41 \cdot 244 -}{\Delta}$$

The great Porosity of Bodies, in this Table, will allow sufficient room within the Bodies, for the electrick Vapour to pass freely through them ; and for the minute Particles of Bodies to move in, and acquire those strong and violent Motions in Fermentations, which make the Particles to meet and clash with great Violence, to grow hot with the Motion, and dash one another to Pieces, and vanish into Air and Vapour and Flame.

Fine

	Density of the Body.	Density of the Æther.	Pores to Solid Parts.
Fine Gold	19.640	0.0050	1.100
Quick-Silver	14.000	0.0714	1.946
Lead	11.325	0.0883	2.641
Fine Silver	11.091	0.0901	2.709
Copper	9.000	0.1111	3.582
Cast Brass	8.500	0.1176	3.851
Steel	7.852	0.1273	4.252
Iron	7.643	0.1308	4.396
Tin	7.320	0.1366	4.498
A Diamond	3.400	0.2941	11.130
Clear Crystal Glafs	3.150	0.3142	12.093
Island Crystal	2.720	0.3676	14.163
Common green Glafs	2.620	0.3820	14.750
Stone of a mean Gravity	2.500	0.4000	15.000
Sal Gem	2.143	0.4666	18.246
Brick	2.000	0.5000	19.622
Nitre	1.900	0.5263	20.707
Dry Ivory	1.825	0.5479	21.599
Brimstone	1.800	0.5555	21.913
Oil of Vitriol	1.700	0.5882	23.261
Pitch	1.150	0.8695	34.864
Amber	1.040	0.9615	38.657
Water (common)	1.000	1.0000	40.244
Bees Wax	0.955	1.0471	42.178
Dry Oak	0.925	1.0832	43.571
— Fir	0.550	1.8181	73.989
— Cork	0.240	4.1666	170.850
Air	0.001 $\frac{1}{4}$	800.0000	32993.480

Experiments prove the *electrical Shock* given to animal Bodies, to be a sudden and violent Contraction of the Muscles; which Contraction is caused by the Explosion of the Vapour, which raises a sudden and strong vibrating Motion in the *Æther* in the Nerves and Membranes of the Muscles.

F I N I S.

.71

.85

.63

A.7
5.4

2.1

3.5

299

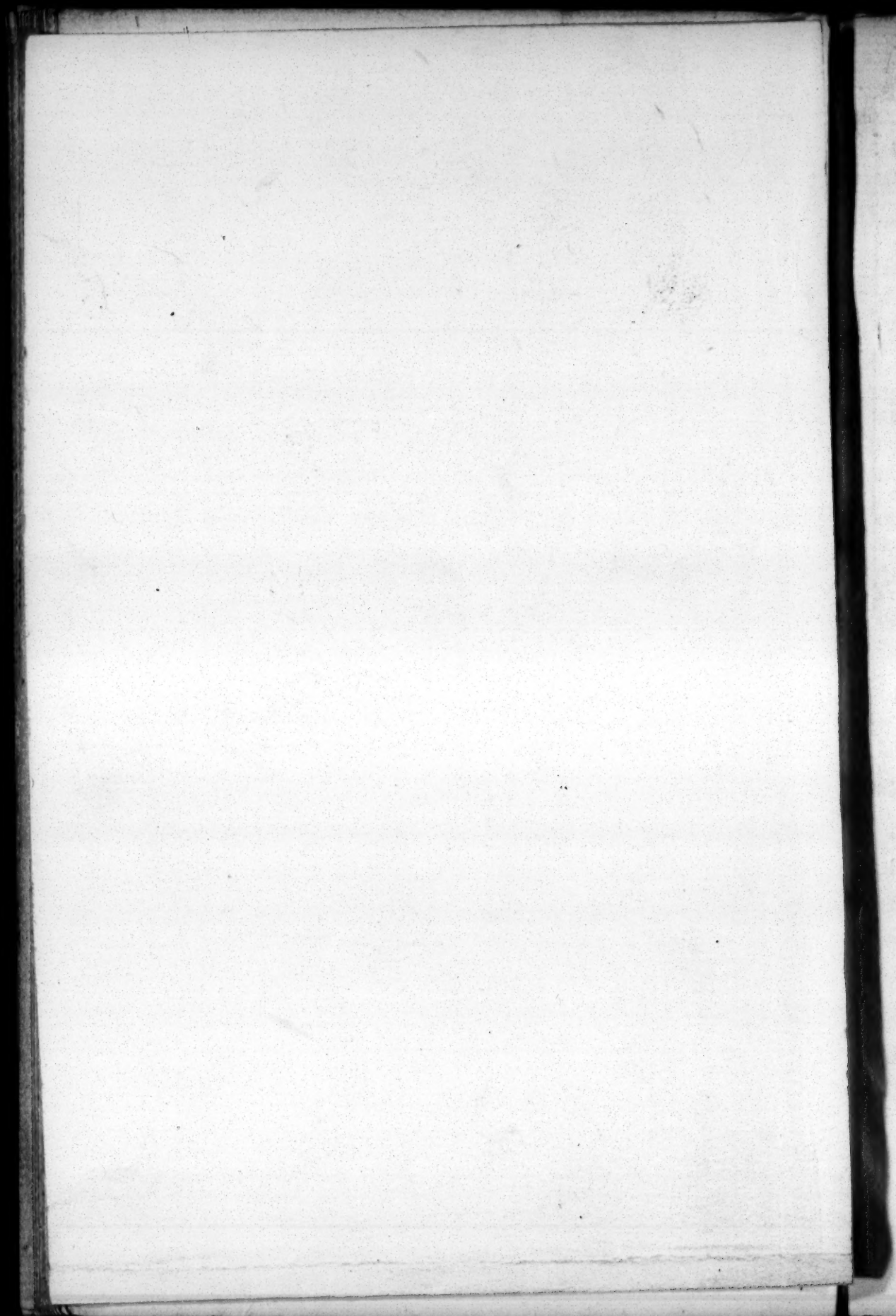


Fig. 1.

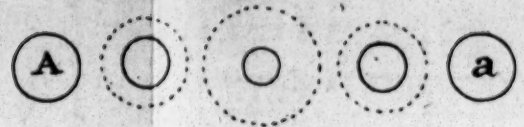


Fig. 2.
P. 29.

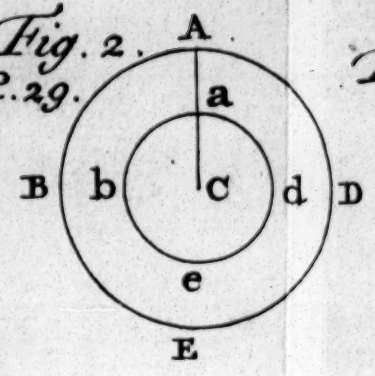


Fig. 3.

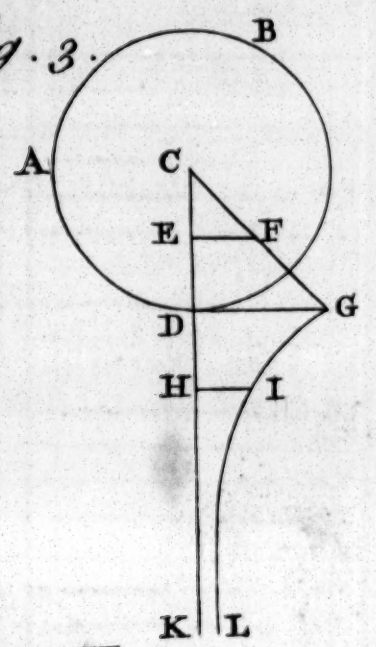


Fig. 4.

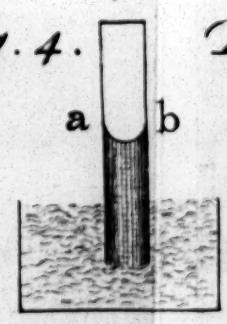
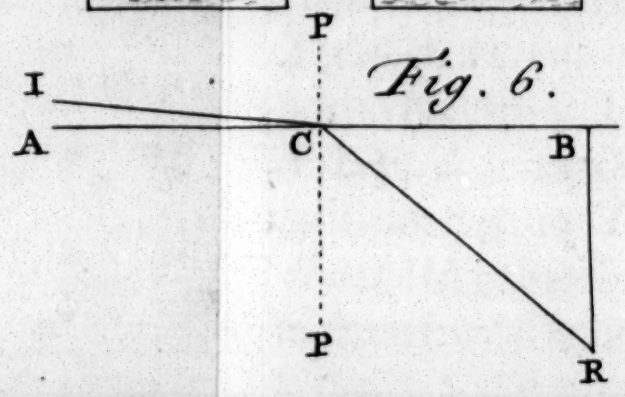
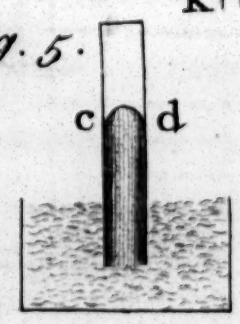


Fig. 5.





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